LAWRENCE WATER WORKS.

REPORTS

ON THE

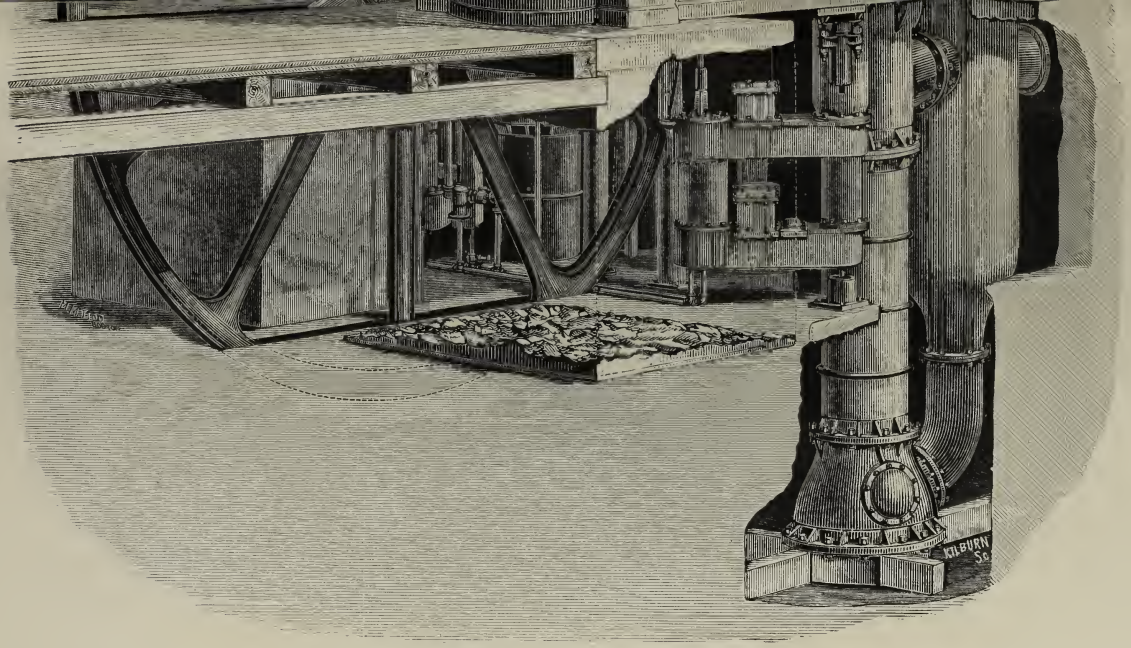
TRIAL OF DUTY AND CAPACITY

OF THE

PUMPING-ENGINES.

May, 1876.

PRINTED BY D. APPLETON & COMPANY, NEW YORK.

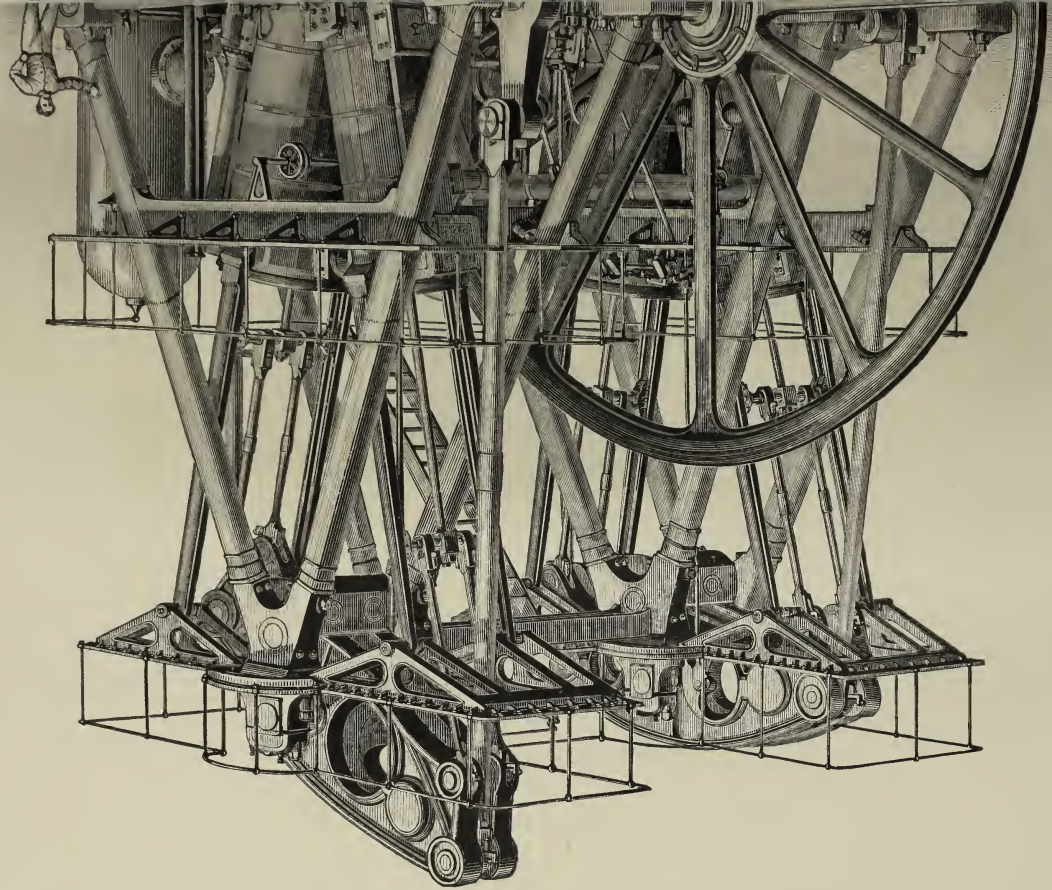


THE LAWRENCE WATER WORKS COMPOUND PUMPING ENGINE.

E. D. LEAVITT JR.'S PATENT.

BUILT BY I. P. MORRIS & CO., PORT RICHMOND IRON WORKS. PHILADELPHIA.

Capacity, 10,000,000 Gallons per 24 Hours.



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FIRST REPORT

OF THE

BOARD OF EXPERTS

ON THE

TEST TRIAL OF THE LAWRENCE PUMPING-ENGINES, TO THE BOARD OF WATER COMMISSIONERS.

To Messrs. William Barbour, Patrick Murphy, and Morris Knowles, Lawrence Water Works Commissioners.

Gentlemen:

Having been selected by the mutual agreement of yourselves as Commissioners, and Messrs. I. P. Morris & Co., contractors, to test the pumping-engine erected by them for your water-works, and determine whether they had furnished engines of capacity and duty, agreeably to the terms of the contract, we entered upon the duties, made the necessary preparations, carried through the test, and now respectfully present our full report of the mode in which the test was conducted, the data collected, and the results arrived at.

For our guidance in the mode of conducting the test, that part of the contract in which this is specified was furnished us. It was as follows:

"For the test the engines shall run for forty-eight consecutive hours, during which the water will be measured over a weir at the reservoir, and the delivery of the pumps must be at the rate of at least 2,000,000 of gallons in ten hours for each engine, with a speed of sixteen revolutions per minute, and a steam-pressure in boiler of 90 pounds per square inch. If, however, the Water Commissioners shall so determine, the test shall last for a less time than forty-eight hours.

"The test shall be made under the direction of at least three mechanical engineers of good reputation, one to be chosen by the Commissioners, one by the said party of the second part, and the third by the other two.

"The coal to be used on the trial shall be the best quality of Cumberland coal, and shall be carefully weighed, and with such precautions as the examiners may determine upon.

"The method of conducting the trials to be as follows: Steam to be raised in the boilers to the proper working-pressure with clean fires of the usual thickness, when the engines are to be started, and the trial is to begin; but the beginning and ending of that portion of the trial on which all calculations of efficiency and duty are based shall be left to the decision of the experts.

"All the coal burned during the trial to be charged without deduction of any kind to the engines.

"The lift to be determined by a correct pressure-gauge attached to the rising main at a point within one hundred feet of the engine-house, to the average readings of which shall be added the pressure due to the difference of the

level of this point, and the mean surface of the water in the pump-well, and also an allowance of one pound per square inch for friction, and bends between the gauge and pump-well.

"The duty obtained must be equal to 95,000,000 pounds lifted one foot high for every 100 pounds of coal consumed in the boiler-furnaces during the trial, and said duty shall be reckoned upon the amount of water delivered over the weir at the reservoir, with five per cent. added thereto to allow for loss of action at the pump.

"At the close of the trial the fires to be in as good condition, and the water in the boiler at the same height, and the steam at the same pressure as at the beginning."

By the terms of the contract, the first item to claim the attention of the experts was that "the coal to be used on the trial shall be of the best quality Cumberland coal, and shall be carefully weighed." All the precautions necessary for the careful weighing were taken by us, but the coal was of such quality of Cumberland as could be readily got; its evaporative capacity will be shown by the result of the experiments.

"The lift to be determined by a correct pressure-gauge attached to the rising main at a point within 100 feet of the engine-house." The gauge was attached to the air-chamber, the readings were taken hourly, and corrected by comparison with a standard gauge. "The pressure due to the difference of level of this point (the gauge) and the mean surface of the water in the pump-well." A floating gauge was put in the pump-well, and referred to the same base as the gauge in the air-chamber. To determine "the amount

of water delivered over the weir at the reservoir" a weir was carefully constructed at the reservoir, observations were taken at no longer intervals than five minutes during the trial, and the quantity estimated by the formula taken from Mr. Francis's "Lowell Hydraulic Experiments."

From a careful determination of the amount of coal used, of the pressure in the main referred to the level of the water in the well, and of the amount of water delivered at the reservoir, and following the method prescribed for firing, the board of experts could have arrived at all the results required by the contract; but it was considered necessary that other data should be obtained, usual in such tests, for comparison of the circumstances under which the engines had been tested, with others, and explanatory of the results arrived at.

At 4.16 P. M., May 1st, the fires were kindled beneath both boilers. At about 6 P. M. the engine was started, and the weir-box filled, and engine stopped to test the leak in rising main and weir-box. At 8.55 P. M. the engine was again started, and at 1 A. M., May 2d, full observations were commenced. The engine was then run continuously till 12.45 A. M., May 3d, when the pipe which had been inserted into the pump-chambers for the taking of indicator-cards blew out, and the engine was stopped till 2.19 A. M., May 3d, when the engine was again started and observations resumed, and continued without interruption till 2 P. M., May 4th, when your Board decided that the engine had been tested sufficiently, and it was stopped, and preparations made for running the two engines coupled.

The engines were coupled and started, and observations were commenced at 7 A. M., May 5th, and continued without interruption till 6 P. M., May 6th.

Calculations were made by us from time to time, during the progress of the test, of the duty and capacity of the engine, and, as it was important that the general result of the test should be known as early as possible, on the afternoon of May 6th the following communication was drawn up and addressed to you:

LAWRENCE, *May* 6, 1876.
PUMPING STATION, LAWRENCE WATER WORKS.

MESSRS. WILLIAM BARBOUR, PATRICK MURPHY, and MORRIS KNOWLES, Lawrence Water Works Commissioners.

GENTLEMEN: In compliance with your request, we have tested the pumping-engines connected with your works. The test was commenced early Tuesday morning, May 2d, and continued through the week, and completed on the afternoon of Saturday, May 6th. The test has been conducted and results calculated conformably to the terms of the contract, and we respectfully report, that the engine has somewhat exceeded the requirements of the contract to lift 95,000,000 pounds one foot high, for every 100 pounds of coal consumed in the boiler furnaces, and the delivery of the pumps, measured by a weir at the reservoir, has exceeded the rate of 2,000,000 gallons in ten hours for each engine.

The engine is new, and the losses by friction, and by want of experience in firing the boilers, have brought down

the duty below 110,000,000 pounds feet, beyond which extra remuneration would have been awarded to the contractor.

The details of the experiments, and the results arrived at, will be given fully at an early date.

With regard to the character of the design, workmanship, and materials, it is of the highest order of mechanical engineering, and we feel sure that in its practical every day working, the engine will be found satisfactory and economical.

(Signed) WM. E. WORTHEN,
J. C. HOADLEY,
JOS. P. DAVIS.

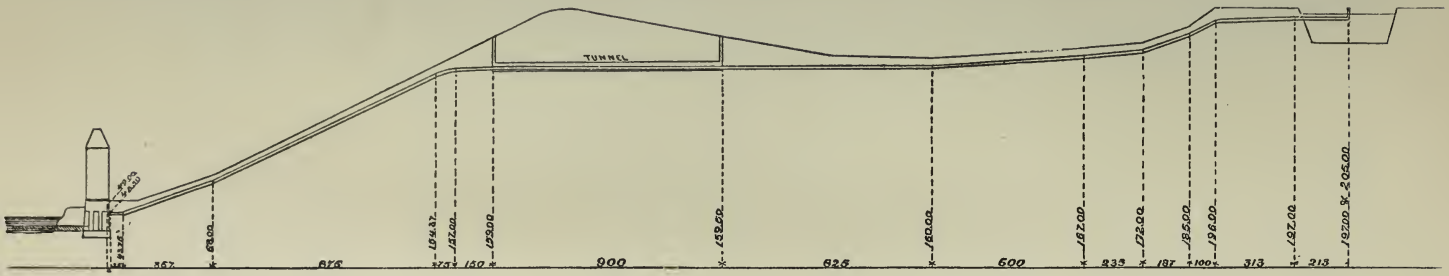
Since this communication all the data obtained during the test have been tabulated in full, and calculations made not only of the requirements of the contracts, but those of general interest and such as obtain usually in experiments of this kind. We propose to give first, those required by the contract, afterward a description of the engine and boilers with the preparations and instruments for the test, the data obtained, calculations of work done in the steam cylinder and in the main, the evaporative work of the boilers, and actual indicator cards compared with theoretical ones.

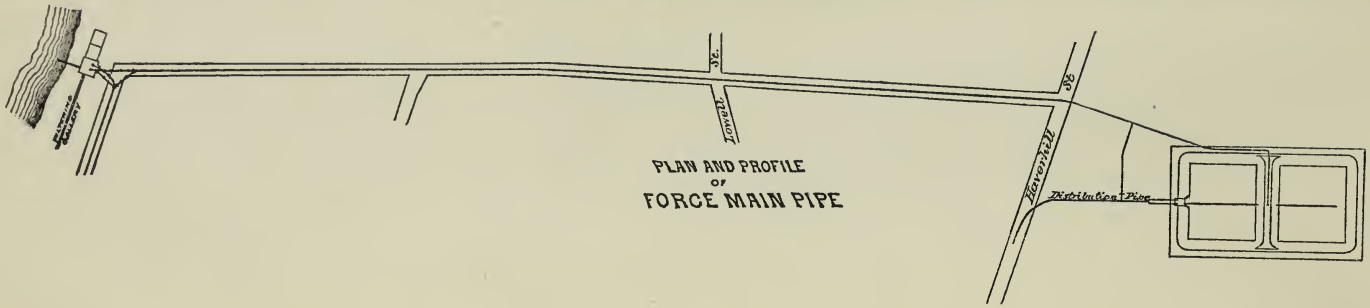
CAPACITY.—From 2 A. M. to 12 midnight, May 2d, 22 hours, there were delivered into the reservoir, as measured by the weir observations taken at intervals of not more than five minutes, 4,527,340 gallons,

or 2,057,881 gallons for each ten hours.

Revolutions, 16.25 per minute; boiler-pressure, 90 pounds.

PLATE I.





PLAN AND PROFILE
OF
FORCE MAIN PIPE

From 3 A. M., May 3d, to 2 P. M., May 4th, 35 hours, the delivery into the reservoir, measured as before, was 7,261,209 gallons,

or 2,074,681 gallons for each ten hours.

Revolutions, 16.29; boiler-pressure, 89 pounds.

The contract is for

2,000,000 gallons in ten hours for each engine,

with a speed of 16 revolutions per minute, and a steam pressure in boiler of 90 pounds per square inch.

DUTY.—The lift, as determined by the terms of the contract, was in the twenty-two hours' test of May 2d, 75.96 pounds, or $75.96 \times 2.31 = 175.47$ feet.

The amount of water delivered at the reservoir was, as above stated, 4,527,340 gallons. The weight of a gallon of water, from the specific gravities taken by Mr. Hasenclever, we estimate at 8.38 pounds, 4,527,340 gallons + 5 per cent., as per terms of contract = $4,753,707 \times 8.38$ pounds = 39,836,064 pounds.

The coal consumed during the time, 7,266 pounds:

$$\frac{175.47 \times 39836064}{7,266} = 962,019 \text{ pounds feet}$$

for the duty of one pound of coal.

In the thirty-five hours' test of May 3d and 4th, the lift was 75.79 pounds = 175.07 feet.

The amount delivered at the reservoir was 7,261,209 gal-

lons, and plus 5 per cent. = 7,624,269 gallons, or 63,891,374 pounds.

The coal consumed during the time 11,630 pounds:

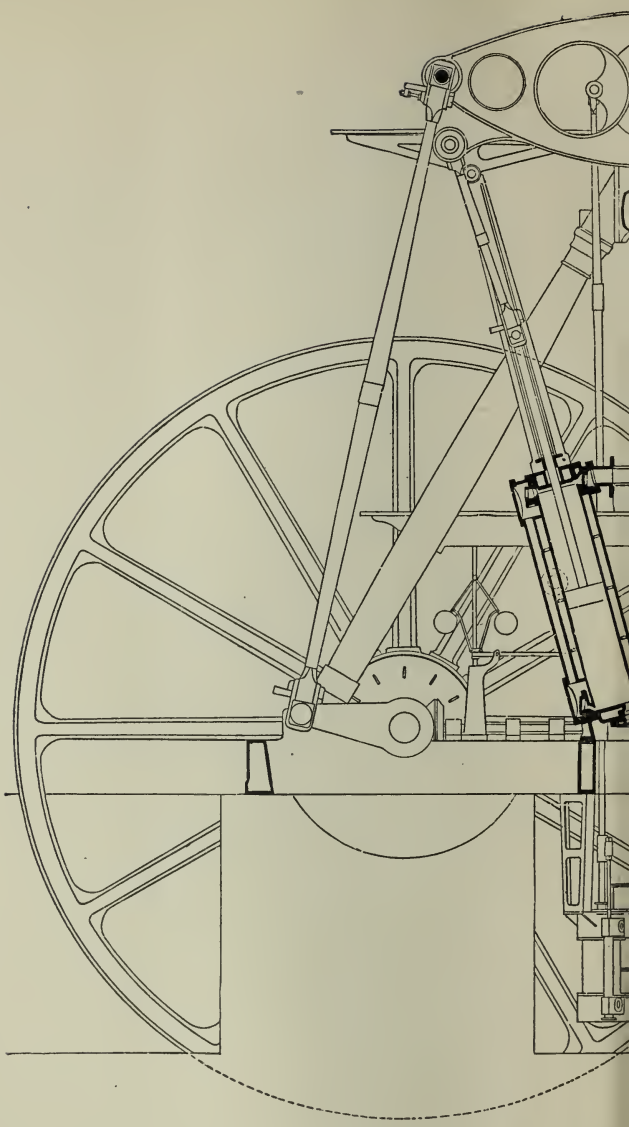
$$\frac{175.07 \times 63,891,374}{11,630} = 961,776 \text{ pounds feet}$$

for the duty of one pound of coal.

The duty to be obtained by the contract must be equal to 95,000,000 pounds lifted one foot high for every 100 pounds of coal consumed in the boiler furnaces. Both results above are in excess of the requirements. The average of the two, or fifty-seven hours, gives 96,186,979 pounds lifted one foot high by 100 pounds of coal.

DESCRIPTION OF WORKS.—Plate I. contains plan and profile of engine-house, main and reservoir, by which their relative positions can be readily understood. The pumps of both engines deliver into branch mains of 24 inches diameter, and 75 feet long, thence by main 30 inches diameter and 4,900 feet long to reservoir. The delivery is usually by an overflow from the upright pipe on the centre of the division-wall of the reservoir; but, for the purpose of measurement by weir, this pipe was enclosed by a box, some 10 feet long by 8 feet wide and 4 feet deep. A weir was constructed on the southerly side, of which the crest was 2 feet 4 inches above the bottom of the platform—or some 4 inches above the top of pipe. The weir measured 3.997 feet in length, plate-iron edge and sides.

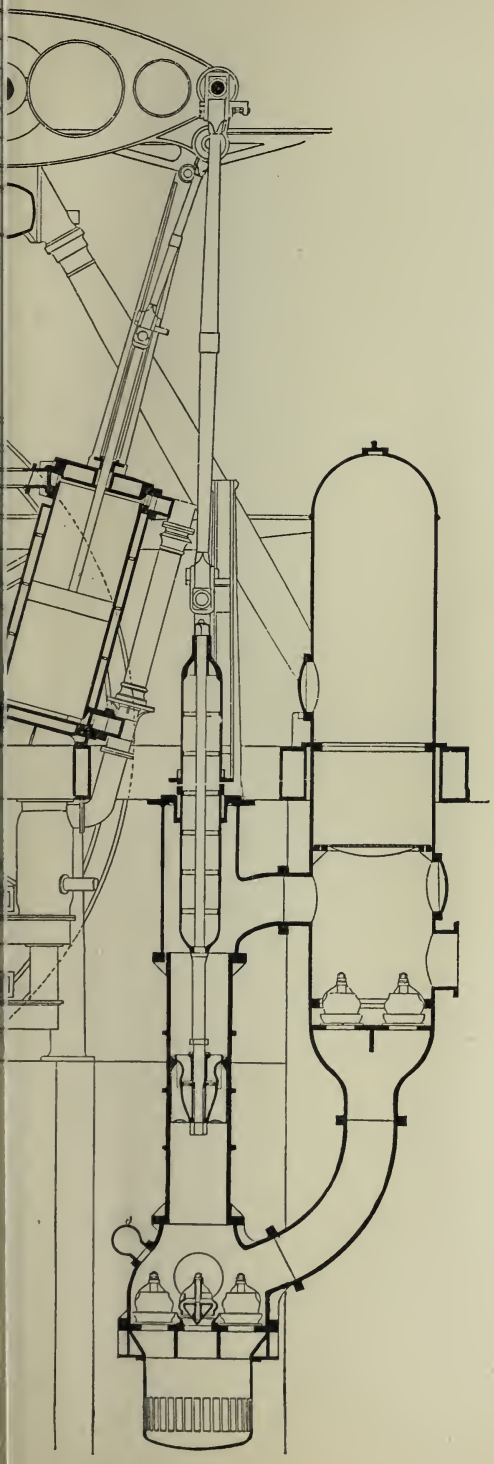
ENGINES.—The engines were two, designated as A and B, with a single fly-wheel between them. For the test of a single engine, the westerly one, or engine B, was run. Plate



LAWRENCE WATER WORKS

ENGINES A&B

E.D. LEAVITT Jr's PATENT 1872



II. is a section of one of the engines—a compound engine of Mr. E. D. Leavitt, Jr.'s, design and patent. The two steam cylinders, both steam jacketted, are placed beneath the main centre of a working beam, and inclined outwardly at the top to connect with opposite ends of the beam, reducing thereby the length of the steam passage between the cylinders, equalizing the stroke, and economizing space, with a strong and compact frame.

The cylinder valves are all gridiron valves with large area of opening and small movement. The steam valves to the high-pressure cylinders are operated by cams controlled by governors, one to each engine. When running coupled, the cam of one engine is set and the other controlled by its governor.

Air-pump double-acting. Feed-pump connected with air-pump rod. The pumps are of the Thames Ditton variety, bucket and plunger, but with a supplementary delivery pipe. There are seven double-beat valves for suction, and four in the supplementary pipe, and the bucket valve for the delivery. Attached to the lower valve chamber, there is a small spherical chamber with an air-cock at the top, by which air may be introduced into the pump, which is found, at particular stages of water in the well, to contribute to ease in the working of the pump.

The boilers are two in number, designed for these works, tubular, with interior fire-boxes; the general construction will be understood from the sections, Plate III. A water mid-feather divides each boiler into two furnaces. This feather extends from the front nearly to the centre of the boiler, where both fire-boxes unite in one combustion cham-

ber. From this chamber the boiler is tubular to the end; the products of combustion passing through the tubes, return beneath nearly to the ash-pit, and pass downward, and laterally into a depressed flue leading to the chimney.

TABLE OF DIMENSIONS.

Diameter of high-pressure cylinders	18 inches.
" low " "	38 "
" high " " rods	3½ "
" low " "	4 "
" air-pumps	15 "
" pump-barrel	26⅛ "
" " plunger	18½ "
" " " rod	4½ "
" bottom and supplementary valves outside lower seat	15¾ "
" " " " " inside upper "	12½ "
" bucket-valves outside lower seat	22 "
" " inside " "	15 "
" air-chamber	54 "
" fly-wheel	30 feet.
Length of stroke of steam and water pistons	8 "
" " air-pump	28 inches
DISTANCES BETWEEN END CENTRES OF BEAM	16½ feet.
Lead on steam-valves	0
" high-pressure exhaust valves	$\frac{1}{16}$ inch.
" low " inlet	$\frac{1}{16}$ "
" " " exhaust bottom	$3\frac{5}{16}$ "
" " " " top	$4\frac{9}{16}$ "
All measured on stroke of pistons.	
Cushion on high-pressure top exhaust	14¼ "
" " bottom "	14¾ "
" low-pressure top "	4½ "
" " bottom "	8¼ "

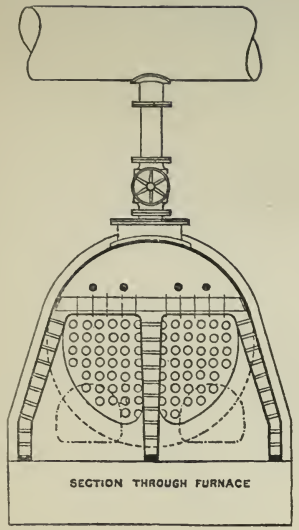
VOLUME OF CLEARANCE AND PORT SPACE:		
High-pressure top	.0256	of cylinder capacity.
" " bottom	.0231	" "
Low " top	.0154	" "
" " bottom	.0182	" "
Connecting pipe between cylinder	.0992	H. P. " "
Weight of fly-wheel	35,900 lbs.	

PLATE III.

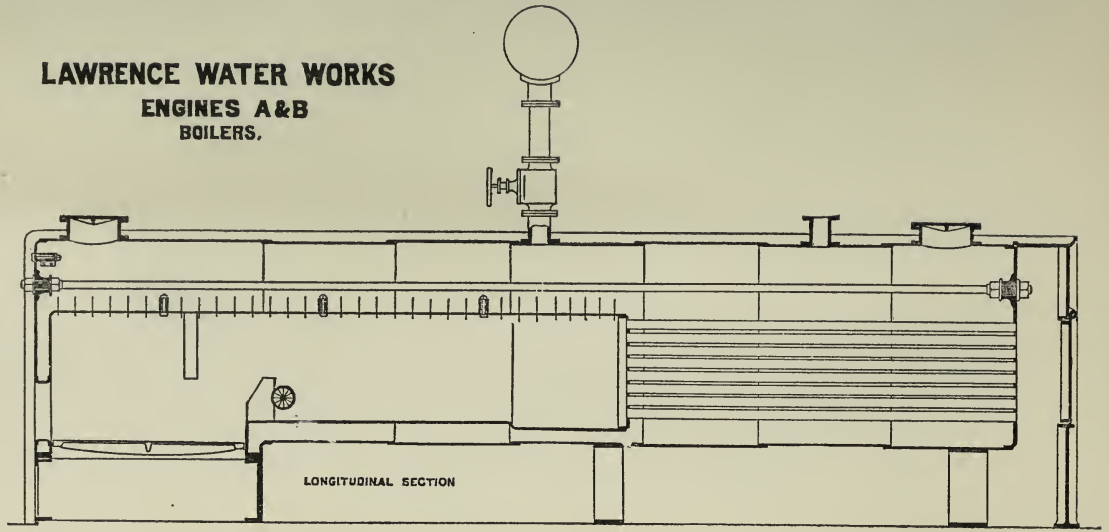
LAWRENCE WATER WORKS

ENGINES A&B

BOILERS.



SECTION THROUGH FURNACE



LONGITUDINAL SECTION

VOLUME OF CLEARANCE AND PORT SPACE:

Weight of walking-beam including pins and counter-balance	25,700 lbs.
" high-pressure piston and connections	2,575 "
" low " " " "	4,175 "
" air-pump " " "	1,800 "
" pump, plunger bucket	7,200 "
" main connections, beam to crank	3,800 "

BOILERS:

Length of shell	25 ft. 5½ in.
" water mid-feather	12 feet.
" combustion chamber	3 "
" tubes	10 "
Diameter of tubes	3 inches.
Number "	80.
Diameter of circular shell	5 ft. 3 in.
Length of each grate	5 feet.
Width " "	2 ft. 10 in.

Steam drum for both boilers, 12 feet 6 × 2 feet.

FORCE MAIN:

Length of force main	4,900 feet.
Diameter " "	30 inches.

Branches from engines to main, 75 feet long × 24 inches diameter.
Static lift from 165 feet to 174 feet.

In preparation for the test a weir was constructed at the reservoir in the usual form, and with all the appliances of gauge-box, connecting-pipe, and hook-gauge. One side of the gauge-box was made of glass for better illuminating the point of the hook in the night.

The scales for weighing the coal were tested; and for determining the quantity fired at any time it was determined to use the car as provided for the works, running it back to the scales and reweighing after each firing.

For measuring the water to be supplied to the boilers two tanks were constructed. The upper or measuring tank was a covered box, in the cover of which a small rectangular opening was made for an overflow; 1,400 pounds of

water at 45° Fahr. were weighed into it, and by the dropping into the tank three bricks previously well wetted, the level of the water was brought up to the level of the overflow. The lower tank, from which the water was fed into the boilers, was provided with a glass gauge graduated from the upper tank. The graduation was from a full tank downward, so that the water fed into the boilers was determined from the number of upper tanks discharged plus that drawn from the lower tank.

The steam gauges on boilers and steam and water on engine were those provided by the contractors. The accuracy of the important ones was determined by a comparison of them with a standard gauge of the American Steam Gauge Company tested by a mercury column.

The thermometers and barometers used were furnished by Huddleston. The thermometers inserted in steam and water passages were made especially for the purpose, the bulbs being enclosed in a tube and the tube inserted into the steam, so that there was no pressure exerted on the bulb. Three thermometers were inserted, one in each of the steam-pipes near the boilers, one in the steam-pipe near the engine, one in each of the jackets of the high and low pressure cylinders, and one in the hot-well delivery-pipe. A tube closed at the lower end and filled with oil was inserted in the main flue for the reception of a thermometer.

A tank with a weir was provided for the reception of the condensed water, and of such capacity as not to be disturbed in its level by the discharge from the hot well.

Indicators were provided and attached to each end of both cylinders, and a pipe connection between the valve-chambers of the pump with a T-pipe for the attachment of an indicator.

TABLE

ENGINE B—TOP OF

Date.	Time.	Forward Stroke.				Backward Stroke.				At 0.05.		At 0.15.		At 0.25.	
		Initial.	Cut off at.	Pressure.	Final.	Initial.	Commencement of Compression.	Pressure.	Final.	+	—	+	—	+	—
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
May 2...	8 A. M.	97.5	.318	100.	36.	32.	.84	11.	52.0	100.2	29.5	100.3	11.20	100.2	11.1
"	9 "	98.5	.312	100.	34.5	29.5	.835	10.5	50.	100.	31.4	100.3	11.	100.5	10.8
"	10 "	99.	.295	100.	34.	29.5	.86	10.	53.	101.0	27.	101.1	10.1	101.	10.5
"	11 "	101.	.298	102.	35.	30.	.84	9.0	52.	102.9	27.8	103.	9.5	102.9	9.9
"	12 M.	100.	.300	101.	35.	31.	.84	9.9	52.	101.1	28.4	101.	10.	101.	10.
"	1 P. M.	103.	.289	104.	34.	29.5	.84	10.	52.5	104.1	27.3	104.2	10.1	104.3	10.1
"	2 "	99.	.310	101.5	35.5	30.5	.835	10.	53.5	102.	29.2	101.9	10.6	101.8	10.5
"	3 "	100.	.280	101.6	32.5	28.5	.84	9.3	53.0	102.	25.6	102.1	9.6	102.1	9.6
"	4 "	103.	.292	103.	33.5	30.0	.835	9.25	52.0	103.4	24.1	103.3	9.5	103.3	9.7
"	5 "	96.5	.310	98.5	34.	30.	.84	9.6	51.	99.	25.4	99.1	9.6	99.1	10.
"	6 "	98.	.296	100.	34.	30.	.825	9.5	51.	100.	26.5	100.	10.	100.	10.5
"	7 "	99.	.308	100.5	34.5	30.	.835	9.5	52.	101.	30.	101.	10.5	101.	10.
"	8 "	100.	.294	101.	32.	27.5	.83	9.	51.	101.	27.	101.3	10.	101.2	9.2
"	9 "	95.	.316	96.	33.3	29.5	.825	9.	50.	96.5	22.5	96.5	10.	96.5	9.4
"	10 "	96.5	.319	96.9	33.6	30.	.83	9.5	50.	97.	29.	97.	10.5	97.	10.
"	11 "	95.	.302	97.5	31.9	28.2	.84	9.5	49.	98.	25.	98.	10.	98.	10.
"	12 "	102.5	.286	102.	32.	28.	.825	8.5	51.	102.5	25.	102.5	10.	102.5	9.
Average.	.....	99.62	.314	100.2	33.84	29.62	.836	9.19	51.47	100.27	27.1	100.74	10.12	100.72	10.
May 3...	3 A. M.	100.	.298	101.	33.	28.5	.835	9.5	52.5	102.1	29.1	102.1	10.8	101.9	10.0
"	4 "	98.5	.293	100.5	33.	29.5	.835	9.5	51.0	101.0	28.1	101.0	9.5	101.0	9.9
"	5 "	96.7	.310	98.7	32.2	28.	.840	9.	51.2	99.9	29.1	100.0	10.0	99.9	9.9
"	6 "	94.	.317	96.	33.5	30.	.860	11.	51.5	96.5	29.0	96.2	10.5	96.5	10.6
"	7 "	91.5	.334	94.	33.5	29.5	.850	10.	52.5	94.2	27.0	94.2	10.0	94.2	10.0
"	8 "	103.5	.292	103.5	34.	29.5	.845	10.	53.5	104.0	29.0	104.0	10.0	103.8	9.9
"	9 "	98.5	.320	99.	35.	30.	.844	10.	52.5	99.5	27.6	99.5	10.5	99.5	10.1
"	10 "	102.	.305	102.5	33.5	30.	.840	9.5	52.5	102.8	28.2	102.8	10.0	102.8	9.9
"	11 "	102.	.300	102.	33.5	29.	.840	9.	52.	102.1	27.6	102.1	10.0	102.0	9.8
"	12 "	99.2	.320	98.	34.2	29.	.835	7.	52.7	100.3	30.1	99.8	10.6	99.5	10.0
"	1 P. M.	100.5	.305	100.1	34.5	29.0	.835	10.	50.	101.2	32.1	101.2	10.9	101.0	10.0
"	2 "	101.5	.320	100.	34.5	30.	.835	10.	51.5	101.5	30.5	101.2	10.7	101.0	10.0
"	3 "	105.5	.292	106.	32.5	28.5	.850	9.	52.5	106.5	27.1	106.5	9.5	106.2	9.3
"	4 "	99.	.305	100.5	33.5	28.5	.850	9.5	52.	101.2	29.1	101.5	9.9	101.0	9.0
"	5 "	105.	.290	104.	32.5	29	.830	10.	51.5	105.1	29.2	105.0	11.0	104.3	10.0
"	6 "	98.5	.315	100.	34.5	30.	.840	10.	51.5	101.2	32.1	101.2	10.8	100.8	10.0
"	7 "	101.5	.304	101.5	32.5	28.5	.835	9.	50.	102.8	28.1	102.6	9.2	102.2	9.1
May 4...	5 A. M.	102.0	.308	100.	34.	29.5	.830	9.	51.5	102.0	30.5	101.5	10.0	101.5	9.9
"	6 "	101.	.308	100.	33.6	29.	.840	9.5	53.	101.0	31.2	101.0	10.4	100.0	10.4
"	7 "	100.	.312	99.5	33.3	29.	.825	8.5	53.	101.0	32.0	100.5	10.0	100.0	9.1
"	8 "	101.	.305	100.	33.8	29.	.830	9.0	52.	101.6	31.5	101.5	10.5	100.9	9.6
"	9 "	93.5	.312	98.5	33.3	29.2	.825	9.5	51.5	99.5	30.5	99.1	10.0	99.0	9.2
"	10 "	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
"	11 "	100.	.303	101.	33.5	29.	.825	9.	52.5	102.0	29.5	101.9	10.1	101.4	9.8
"	12 "	100.5	.309	100.	33.2	28.5	.835	9.	52.	102.0	30.5	101.6	10.5	100.5	9.1
"	1 P. M.	106.	.294	106.	33.5	28.5	.830	9.	52.5	106.2	31.0	106.0	10.0	106.0	10.0
"	2 "	98.8	.310	99.	33.0	29.	.835	8.5	50.	100.0	27.6	100.0	10.0	100.0	9.1
Average.	.....	100.2	.307	100.4	33.4	28.35	.837	9.35	51.80	101.2	29.51	101.3	10.19	101.03	9.76

No. I.

HIGH-PRESSURE CYLINDER.

At 0.35.		At 0.45.		At 0.55.		At 0.65.		At 0.75.		At 0.85.		At 0.95.		Net Average.	Planimeter.
+	—	+	—	+	—	+	—	+	—	+	—	+	—		
15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
91.4	11.90	71.30	13.00	59.6	14.3	50.89	16.1	44.5	18.4	40.2	21.0	37 1	26.0	52.30	51.60
89.6	11.4	71.	11.7	59.1	13.8	50.	14.6	44.	17.	39.4	20.	36.4	24.5	52.4	52.0
84.1	11.1	67.8	12.1	55.3	13.2	47.1	14.2	41.9	16.9	37.4	14.9	34.9	24.5	51.7	51.6
86.3	10.6	69.1	11.8	57.1	13.	48.6	14.6	42.8	17.2	38.8	20.6	35.8	25.5	52.66	52.40
87.1	11.	68.9	12.	56.6	13.1	48.5	14.6	42.3	16.6	38.4	19.8	35.0	25.	51.86	52.00
86.6	11.	67.5	11.8	56.	13.2	48.1	14.6	42.	17.	38.1	19.9	35.1	24.9	52.6	52.4
90.5	11.	70.2	12.4	57.4	13.9	49.3	15.	43.1	17.8	39.3	20.5	36.6	25.1	52.6	52.
82.0	10.	64.1	10.9	53.1	12.1	45.8	13.9	40.1	15.9	36.	18.8	33.	23.	51.11	51.2
85.4	10.5	67.5	11.6	56.	12.8	47.8	14.5	42.1	16.8	37.5	19.4	34.5	24.2	52.7	52.4
87.	10.1	68.6	11.3	57.	12.8	48.1	14.5	42.1	16.2	38.1	19.2	35.	23.6	52.04	51.60
86.	11.	68.	12.2	56.	13.2	49.	15.	42.1	16.6	38.	20.	35.	25.	51.41	52.
88.5	10.5	69.	11.8	57.	13.	49.	15.	43.	16.5	38.5	19.5	35.	24.5	52.02	51.60
85.	10.	66.	11.	54.5	12.5	46.5	14.	41.	16.3	37.5	18.	34.5	23.	51.85	52.00
86.5	10.2	69.	11.5	55.5	12.9	47.6	14.7	42.5	16.2	38.	19.	34.	23.5	50.27	50.40
87.	10.5	68.5	11.3	56.	12.5	48.3	14.6	42.	16.2	38.	20.	34.5	24.	50.67	50.80
83.5	10.5	65.5	11.5	54.5	12.5	46.5	14.7	40.5	17.	36.	20.	33.	24.	50.71	50.40
82.5	10.0	65.	11.2	54.	12.	46.2	14.2	40.5	16.	36.2	19.	33.5	24.	51.5	51.60
86.41	10.6	68.05	11.71	56.15	12.98	48.02	14.6	42.14	16.74	37.96	19.38	34.75	24.54	51.79	51.64
85.4	10.5	67.1	11.6	55.1	12.8	47.1	14.6	41.4	17.0	37.0	19.8	34.0	23.4	51.35	51.60
85.1	10.2	65.6	11.0	54.1	12.4	46.2	14.1	41.0	16.5	37.1	20.0	34.2	24.2	51.04	51.20
86.5	10.2	72.0	11.3	55.2	12.7	46.8	14.0	40.8	16.1	37.0	19.0	33.1	23.1	51.67	51.20
86.2	11.0	68.0	12.2	56.1	13.2	48.0	14.6	42.6	17.2	38.6	20.0	35.5	24.2	50.16	50.00
89.5	10.9	69.0	11.8	57.8	13.2	48.8	14.6	42.5	16.8	38.0	19.3	35.0	24.0	50.56	50.40
85 5	10.8	67.1	12.0	56.0	13.0	48.0	14.6	42.0	16.5	38.0	19.5	34.8	24.0	53.38	53.20
90.1	10.9	69.8	11.7	58.0	13.2	49.2	14.6	43.2	17.0	39.0	20.5	35.9	24.8	52.18	52.40
86.5	10.5	67.6	11.1	56.0	12.6	48.0	14.1	42.0	16.2	38.0	19.4	35.0	24.2	52.53	52.80
85.5	10.2	67.0	11.2	54.6	12.5	47.5	14.3	41.3	15.1	37.1	19.1	34.1	23.4	52.10	52.40
89.5	10.8	68.8	11.6	56.5	13.0	48.5	14.7	42.0	16.8	37.8	19.8	34.9	24.1	51.60	52.40
89.1	10 5	68.6	11.5	56.6	12.8	48.5	14.7	42.5	16.9	38.3	19.6	35.4	23.8	51.94	52.00
89.1	11.1	69.1	12.2	56.5	13.5	48.8	14.7	43.0	17.0	39.0	19.8	35.4	25.0	52.00	52.80
83.8	10.0	65.5	11.5	54.2	13.0	45.6	14.1	40.5	16.5	36.1	19.0	33.1	23.0	52.55	53.20
86.2	10.0	67.4	11.2	55.1	12.1	47.3	14.0	41.8	16.2	37.4	19.2	34.2	24.0	52.83	52.80
85.2	10.5	65.5	11.2	54.8	12.6	46.6	14.2	41.1	15.2	37.1	19.2	34.0	23.6	52.20	52.80
89.4	11.0	68.6	11.8	56.6	13.0	48.3	14.5	42.6	16.7	39.1	20.0	35.0	24.5	51.84	52.00
84.0	10.0	66.1	10.9	54.3	12.2	46.2	14.0	41.0	16.2	36.6	19.5	33.8	24.0	51.64	51.60
86.1	10.0	66.8	10.7	55.1	12.3	47.2	13.5	41.5	15.5	37.5	19.0	34.6	23.5	51.90	52.40
88.6	10.0	68.8	11.2	56.0	12.0	48.0	14.3	42.0	16.0	37.4	18.5	34.1	23.4	51.95	52.00
85.7	9.8	66.2	11.1	54.9	12.0	47.0	13.5	41.5	15.5	37.2	19.0	33.6	23.3	51.23	51.20
85.4	10.0	67.5	11.0	55.1	12.1	47.5	14.0	41.6	15.6	37.0	18.5	34.0	23.8	51.55	51.60
87.0	10.0	67.2	11.0	55.0	12.2	47.4	13.7	41.9	15.0	37.4	18.8	34.2	24.0	51.27	51.60
86.1	10.1	66.8	11.1	55.1	12.1	47.6	14.6	42.0	16.0	37.2	18.8	34.0	23.2	51.88	52.40
85.4	10.1	68.1	11.0	56.1	12.0	47.0	14.5	42.0	15.9	37.2	18.8	34.4	23.8	51.81	52.00
86.5	10.0	66.5	11.2	54.6	12.8	47.3	14.0	41.5	16.0	37.3	19.0	34.1	23.0	52.90	53.20
85.0	10.0	65.6	10.5	54.5	12.0	46.3	13.2	40.3	14.7	36.8	18.8	34.5	23.0	51.49	51.60
86.63	10.35	67.55	11.33	55.63	12.59	47.49	14.23	41.86	16.16	37.55	19.30	34.42	23.78	51.83	52.03

TABLE

ENGINE B—TOP OF

Date.	Time.	Forward Stroke.		Backward Stroke.		At 0.05.		At 0.15.		At 0.25.		At 0.35.	
		Initial.	Final.	Initial.	Final.	+	—	+	—	+	—	+	—
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
May 2...	8 A. M.	26.5	5.6	4.5	.....	24.	1.5	19.	1.6	16.2	1.8	14.2	1.9
"	9 "	26.1	6.	5.	.....	24.5	1.7	19.5	1.7	16.8	1.7	14.	1.9
"	10 "	25.2	5.6	5.	.....	22.	1.7	18.8	1.8	15.9	1.8	13.4	2.
"	11 "	25.0	6.4	5.	.....	23.1	1.8	18.4	1.8	15.7	1.9	13.5	2.
"	12 "	25.0	6.5	5.	.....	24.	1.6	19.1	1.6	16.	1.7	13.9	1.8
"	1 P. M.	26.5	6.5	5.	.....	24.	1.8	19.3	1.8	16.1	1.9	14.	2.
"	2 "	26.	6.5	5.	.....	24.2	1.6	19.6	1.6	16.6	1.6	14.3	1.9
"	3 "	25.	6.	4.5	.....	23.2	1.6	18.6	1.6	15.8	1.8	13.4	1.9
"	4 "	24.7	6.	4.4	.....	23.3	1.6	18.9	1.7	16.	1.8	13.8	2.
"	5 "	25.7	6.	4.	.....	24.	1.9	19.4	2.	15.2	2.	14.	2.1
"	6 "	27.5	6.3	4.	....	23.5	1.8	18.8	1.5	15.8	1.5	13.6	1.6
"	7 "	27.	6.8	4.	.....	23.1	1.6	19.	1.7	16.	1.8	13.8	1.8
"	8 "	26.7	6.3	3.5	.....	23.	1.4	18.2	1.5	15.8	1.5	13.5	1.7
"	9 "	26.8	6.	3.6	.....	22.3	1.	17.5	1.1	14.9	1.1	12.9	1.2
"	10 "	27.8	6.3	3.9	.....	22.8	1.3	18.5	1.3	15.5	1.3	13.5	1.6
"	11 "	26.	6.0	3.4	.....	22.2	1.2	18.	1.2	15.3	1.5	13.	1.7
"	12 "	27.	5.7	3.8	.....	22.2	1.	18.	1.1	15.1	1.1	13.1	1.2
Average.	.....	26.14	6.14	4.32	.....	23.14	1.53	18.74	1.56	15.81	1.69	13.05	1.84
May 3...	3 A. M.	25.1	5.6	3.5	.....	23.1	1.7	18.6	1.7	15.6	1.8	13.4	1.9
"	4 "	27.5	6.5	3.5	5.8	23.1	1.4	18.6	1.5	15.6	1.5	13.4	1.6
"	5 "	27.1	5.8	3.6	6.	22.4	1.5	18.2	1.7	15.6	1.8	13.4	1.9
"	6 "	27.2	5.5	4.5	6.5	23.2	1.1	18.6	1.2	15.6	1.2	13.6	1.5
"	7 "	28.1	5.	4.	9.	22.0	1.2	18.1	1.2	15.5	1.4	13.5	1.4
"	8 "	25.	6.7	4.5	.....	23.9	1.8	19.5	1.8	16.3	1.8	14.2	2.0
"	9 "	25.5	6.5	4.5	.....	24.8	1.7	20.1	1.8	16.8	1.8	14.4	1.9
"	10 "	25.5	6.	4.5	.....	23.8	1.8	19.3	1.9	16.3	1.9	14.1	2.2
"	11 "	26.5	6.7	3.5	.....	23.6	1.3	19.0	1.4	15.8	1.6	13.8	1.9
"	12 M.	27.9	6.	3.5	.....	23.4	1.4	19.0	1.6	16.2	1.6	14.0	1.7
"	1 P. M.	27.6	5.5	3.2	.....	23.2	1.3	18.9	1.6	16.1	1.6	14.0	1.6
"	2 "	26.	5.2	3.7	.....	25.0	1.5	18.9	1.5	16.1	1.7	13.7	1.7
"	3 "	26.6	5.5	3.8	.....	22.6	1.6	18.4	1.8	15.8	1.9	13.7	2.1
"	4 "	27.0	5.5	3.5	.....	23.3	1.3	18.8	1.4	16.0	1.5	13.6	1.8
"	5 "	27.6	5.5	4.	.....	23.3	1.6	18.8	1.7	15.6	1.8	13.8	1.8
"	6 "	27.5	5.5	4.2	.....	23.8	1.6	18.9	1.6	16.0	1.6	13.8	1.7
"	7 "	27.	7.	3.5	.....	23.6	1.6	19.2	1.5	16.2	1.6	14.1	1.7
May 4...	5 A. M.	27.2	6.0	7.0	4.6	24.8	1.6	19.1	1.6	16.4	1.8	14.3	2.0
"	6 "	27.6	7.4	5.6	4.0	23.2	1.6	18.5	1.7	15.8	1.8	13.8	1.8
"	7 "	27.	5.6	5.8	3.5	22.1	1.4	18.0	1.4	15.4	1.4	13.2	1.7
"	8 "	27.3	5.8	5.5	4.	22.6	2.0	18.6	2.0	16.0	2.0	14.0	2.2
"	9 "	27.4	7.0	5.6	3.8	23.4	1.8	18.8	1.8	14.8	1.8	13.8	1.8
"	10 "	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
"	11 "	26.6	6.2	5.6	3.5	21.8	1.5	18.0	1.5	15.4	1.6	13.2	1.7
"	12 M.	27.6	5.1	6.0	3.8	23.2	1.7	19.0	1.8	16.1	1.9	14.0	2.0
"	1 P. M.	26.8	6.9	5.3	3.7	22.8	1.5	18.0	1.6	15.7	1.7	13.4	1.8
"	2 "	27.1	5.1	6.0	4.4	22.9	1.6	19.1	1.6	16.1	1.8	13.8	1.9
Average.	.....	26.90	5.95	4.53	.....	23.26	1.54	18.78	1.61	15.88	1.65	13.77	1.82

No. II.

LOW-PRESSURE CYLINDER.

At 0.45.		At 0.55.		At 0.65.		At 0.75.		At 0.85.		At 0.95.		Net Average.	Planimeter.
+	—	+	—	+	—	+	—	+	—	+	—		
13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.
12.7	2.1	11.4	2.3	10.5	2.5	9.7	2.5	9.1	2.7	8.2	3.1	11.32	11.04
12.9	2.	11.6	2.5	10.6	2.5	9.7	2.6	9.1	2.7	5.7	3.	11.23	11.40
12.	2.	10.9	2.1	9.8	2.1	9.1	2.4	8.4	2.5	7.3	2.9	10.78	10.68
12.	2.1	10.9	2.3	9.8	2.4	9.1	2.4	8.3	2.6	7.6	3.2	10.59	10.32
12.4	2.	11.1	2.	10.1	2.1	9.3	2.4	8.8	2.7	7.8	3.1	11.14	10.80
12.4	2.1	11.2	2.3	10.2	2.3	9.5	2.4	8.8	2.6	7.9	3.1	11.10	10.92
12.7	2.	11.3	2.	10.4	2.1	9.6	2.6	8.9	2.8	8.	3.3	11.41	11.04
12.	2.	10.9	2.	9.9	2.2	9.1	2.3	8.4	2.4	7.6	2.8	10.77	10.68
12.2	2.3	11.	2.3	10.	2.4	9.2	2.4	8.6	2.5	7.6	3.	11.25	10.86
12.3	2.2	11.2	2.3	10.3	2.6	9.5	2.7	8.9	2.8	7.9	3.1	10.90	10.68
12.	1.8	11.	2.	9.9	2.	9.2	2.1	8.6	2.3	7.6	2.7	11.12	11.07
12.3	2.	11.1	2.	10.2	2.2	9.5	2.2	8.8	2.5	8.	3.	11.10	11.04
12.	2.	10.9	2.1	9.9	2.1	9.1	2.3	8.5	2.5	7.7	2.7	10.82	10.68
11.3	1.6	10.1	1.8	9.2	1.8	8.8	1.9	8.1	2.1	7.2	2.3	10.64	10.68
12.2	1.7	11.	1.8	10.	1.9	9.	1.9	8.2	2.1	7.5	2.5	11.08	10.91
11.7	1.8	10.3	1.9	9.5	2.	8.8	2.	7.9	2.1	7.2	2.2	10.63	10.44
11.8	1.3	10.5	1.6	9.6	1.8	9.	2.	8.2	2.2	7.3	2.3	10.92	10.80
12.17	1.94	10.96	2.07	10.05	2.17	9.24	2.30	8.86	2.49	7.53	2.84	10.98	10.85
11.8	2.1	10.7	2.2	9.8	2.2	9.1	2.2	8.3	2.3	7.5	2.8	10.72	10.81
12.0	1.9	10.9	2.0	10.0	2.2	9.2	2.2	8.5	2.4	7.6	3.0	10.83	11.04
12.1	2.0	11.0	2.1	9.9	2.2	9.1	2.2	8.5	2.5	7.6	2.8	10.91	10.68
12.0	1.7	10.7	1.8	9.8	1.9	9.0	2.0	8.2	2.1	7.2	2.6	11.10	10.92
11.9	1.8	11.0	1.9	9.9	1.9	9.1	2.0	8.3	2.1	7.5	2.5	10.93	10.80
12.5	2.0	11.2	2.1	10.2	2.2	9.5	2.6	8.9	2.8	8.0	3.1	11.21	11.04
12.9	2.1	11.4	2.2	10.3	2.2	9.8	2.5	9.0	2.8	8.1	3.3	11.53	11.16
12.5	2.5	11.2	2.5	10.2	2.5	9.5	2.7	8.7	2.8	7.8	3.1	10.95	10.80
12.1	2.0	11.1	2.2	10.0	2.3	9.2	2.4	8.6	2.5	7.8	2.8	11.07	11.28
12.9	1.9	11.1	2.0	10.2	2.1	9.4	2.1	8.8	2.3	7.8	2.8	11.14	11.28
12.3	1.8	11.3	2.0	10.3	2.0	9.5	2.1	8.9	2.3	8.0	2.8	11.33	11.28
12.1	1.9	11.1	2.0	10.0	2.0	9.4	2.1	8.6	2.3	7.9	2.7	11.33	11.04
12.0	2.0	11.0	2.0	10.0	2.0	9.0	2.0	8.4	2.1	7.6	2.4	10.91	10.56
12.0	1.9	11.0	2.0	10.0	2.1	9.2	2.1	8.5	2.4	7.8	2.5	11.02	10.20
12.2	2.0	11.1	2.2	10.1	2.2	9.2	2.4	8.5	2.4	7.7	2.7	10.96	10.80
12.3	1.9	11.3	2.0	10.3	2.1	9.5	2.1	8.9	2.3	8.0	2.8	11.19	11.16
12.6	1.9	11.3	2.0	10.4	2.1	9.7	2.2	9.0	2.3	8.1	2.7	11.46	11.28
12.5	2.0	11.3	2.2	10.4	2.4	9.9	2.6	9.0	2.8	8.3	2.4	11.36	11.16
12.1	2.0	11.2	2.1	10.1	2.2	9.3	2.4	8.8	2.6	8.0	2.9	10.99	10.80
11.7	1.8	10.6	2.0	9.8	2.0	9.0	2.1	8.3	2.2	7.4	2.7	10.67	10.56
12.1	2.3	11.1	2.4	10.1	2.5	9.3	2.5	8.6	2.7	7.8	3.0	10.67	10.56
12.2	2.0	11.0	2.0	10.0	2.1	9.2	2.3	8.6	2.4	7.8	2.8	10.78	10.68
11.7	1.8	10.8	1.9	9.8	2.0	9.0	2.1	8.4	2.4	7.6	2.8	10.68	10.64
12.3	2.2	11.2	2.2	10.2	2.3	9.4	2.4	8.6	2.4	7.9	2.8	11.02	10.92
11.8	1.9	10.8	2.0	9.9	2.0	9.0	2.0	8.1	2.3	7.6	2.7	10.77	10.68
12.0	2.0	10.8	2.1	10.0	2.2	9.4	2.3	8.7	2.6	7.9	2.8	10.98	10.68
12.18	1.98	11.05	2.05	10.06	2.15	9.30	2.26	8.60	2.43	7.78	2.78	10.97	10.76

TABLE

ENGINE B—BOTTOM OF

Date.	Time.	Forward Stroke.				Backward Stroke.				At 0.5.		At 0.15.		At 0.25.	
		Initial.	Cut off at.	Pressure.	Final.	Initial.	Commencement of Compression.	Pressure.	Final.	+	—	+	—	+	--
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
May 2...	8 A. M.	102.	.325	100.	36.5	29.	.85	10.9	56.	102.5	29.2	102.5	10.9	102.5	11.0
"	9 "	103.5	.326	103.5	36.	28.	.82	11.5	53.5	103.5	29.9	103.6	11.1	104.	11.
"	10 "	104.	.321	105.	35.	28.5	.85	11.5	62.5	104.6	29.1	104.6	11.	104.8	11.1
"	11 "	101.	.320	101.5	34.	28.	.85	11.5	59.5	101.	29.5	101.5	11.	101.5	11.
"	12 "	105.5	.303	105.5	35.	27.5	.85	11.5	59.5	106.	26.7	106.1	10.4	106.1	10.8
"	1 P. M.	103.5	.310	103.5	34.5	28.0	.85	11.5	60.	104.	26.8	104.	11.	104.	11.
"	2 "	106.5	.290	107.	35.	27.5	.85	11.	54.5	106.8	22.1	107.	10.6	107.	10.8
"	3 "	106.5	.290	106.5	33.5	28.0	.83	9.5	62.5	106.8	27.5	107.	10.	107 3	9.
"	4 "	102.	.307	102.5	34.5	29.5	.835	9.5	61.	102.1	29.6	102.1	10.	102.1	8.9
"	5 "	100.5	.324	101.5	35.5	28.5	.835	8.0	62.	101.7	26.3	101.7	8.3	102.	8.5
"	6 "	102.8	.326	101.5	35.	29.	.83	9.0	60.	102.5	28.	102.5	10.	102.5	9.1
"	7 "	102.5	.312	103.	36.	28.	.8	8.2	57.	103.	25.5	103.	10.2	103.	9.
"	8 "	100.	.330	100.	35.3	29.	.825	9.5	56.	100.	28.5	100.	10.0	100.	9.7
"	9 "	97.	.331	96.5	34.5	29.	.825	8.5	61.2	97.	27.	97.	10.	97.	9.
"	10 "	100.	.318	99.	35.	30.	.835	8.5	60.	100.	25.	100.	8.9	100.	8.5
"	11 "	100.	.308	99.2	33.	28.5	.83	9.5	60.	101.	27.	101.	10.	101.	10.
"	12 "	104.5	.313	105.	36.	30.5	.82	9.3	61.5	105.	27.5	105.	10.5	105.	9.5
Average.	.....	103.0	.315	102.4	34.9	28.6	.840	9.9	59.2	102.7	27.3	102.8	10.21	102.9	9.8
May 3...	3 A. M.	101.	.301	102.	34.5	28.5	.84	8.	58.5	101.4	27.5	101.0	8.5	101.5	8.9
"	4 "	103.	.310	103.5	35.	27.5	.84	8.5	59.5	103.5	26.5	103.1	9.0	103.5	8.5
"	5 "	98.	.313	98.	34.	28.	.835	8.	63.	98.3	29.6	98.5	9.4	98.5	9.0
"	6 "	95.5	.327	96.	36.	30.	.835	9.	59.	96.5	26.4	96.5	9.0	96.8	9.9
"	7 "	97.5	.325	97.5	35.	30.	.85	9.	58.	98.0	25.1	97.5	9.0	97.5	9.2
"	8 "	105.	.306	106.	36.5	29.5	.835	8.	60.	105.2	24.0	105.6	8.9	105.5	8.2
"	9 "	101.	.313	101.5	36.	27.8	.830	7.5	59.5	101.1	29.1	101.8	8.6	101.8	7.9
"	10 "	103.	.311	104.	35.5	28.	.84	9.0	64.	104.0	29.6	104.0	9.4	104.0	8.6
"	11 "	105.	.298	106.	36.	28.5	.835	8.5	63.	105.0	25.1	105.5	9.1	106.0	9.1
"	12 "	101.	.316	102.	36 5	29.5	.85	7.5	63.5	101.5	25.0	101.5	8.1	101.6	8.0
"	1 P. M.	103.	.314	104.5	36.	28.	.84	8.5	61.5	104.0	27.5	104.0	8.8	104.0	8.5
"	2 "	103.5	.324	103.	36.5	28.5	.84	9.0	60.5	104.0	27.9	104.0	9.2	103.9	9.1
"	3 "	98.5	.318	99.5	33.5	27.5	.84	8.0	59.5	100.0	27.3	100.0	8.1	100.0	8.3
"	4 "	103.	.315	103.	34.5	28.	.83	8.5	62.	103.1	27.0	103.0	9.0	102.8	7.8
"	5 "	103.5	.312	104.	34.5	28.	.83	8.5	60.	103.8	26.5	104.0	9.1	104.0	8.9
"	6 "	105.	.308	105.	35.5	27.5	.835	8.0	58.5	105.2	28.1	105.2	8.9	105.2	8.5
"	7 "	101.5	.306	102.5	34.	27.	.835	8.0	61.	102.1	26.5	102.4	8.1	102.5	8.2
May 4...	9 A. M.	99.5	.318	99.1	36.2	29.0	.84	8.9	62.5	99.8	24.8	99.5	9.0	99.5	8.9
"	10 "	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
"	11 "	101.	.324	101.	35.0	27.5	.825	7.9	63.2	101.5	29.5	101.1	9.0	101.2	8.9
"	12 "	97.	.382	96.5	36.8	29.0	.835	8.5	58.0	97.2	23.1	97.0	9.0	97.0	9.0
"	1 P. M.	105.	.300	104.8	35.2	27.5	.845	8.7	62.	105.0	27.0	104.9	8.9	105.0	9.0
"	2 "	101.	.315	101.2	34.5	27.5	.83	8.2	63.	101.0	25.8	101.0	9.1	101.2	8.5
Average.	.....	101.2	.316	101.8	34.8	28.4	.842	8.3	60.92	101.37	26.77	101.87	8.87	101.95	8.68

No III.

HIGH-PRESSURE CYLINDER.

At 0.35.		At 0.45.		At 0.55.		At 0.65.		At 0.75.		At 0.85.		At 0.95.		Net Average.	Planimeter.
+	—	+	—	+	—	+	—	+	—	+	—	+	—		
15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
94.	10.8	72.3	11.	59.9	11.1	51.0	12.8	44.9	14.5	40.2	17.9	37.	23.2	55.43	55.2
96.8	10.9	73.2	11.	59.8	11.2	51.5	12.8	45.1	14.6	40.8	18.	37.1	22.8	56.21	56.4
92.1	11.	71.5	11.	59.2	11.5	50.2	13.2	44.1	15.3	40.	18.5	36.	23.2	55.12	54.8
90.5	11.	69.	11.3	57.5	11.2	49.1	13.	43.	14.7	38.1	18.2	35.	23.1	53.31	52.8
88.4	11.	69.1	11.1	57.2	11.1	50.1	12 3	43.2	14.5	39.1	18.	35.3	22.9	55.20	55.2
88.5	11.1	70.5	11.2	58.8	11.8	49.6	12.7	43.5	14.6	39.4	17.6	36.0	22.9	54.70	54.4
89.	11.	69.2	11.2	57.	11.5	48.8	12.1	43.1	14.1	39.	17.5	38.8	22.3	55.95	56.0
87.1	9.8	68.2	10.4	57.1	11.8	49.	13.9	43.1	15.2	38.2	18.5	35.2	23.	54.89	54.4
89.2	10.	70.	10.5	58.1	11.6	49.4	13.2	43.1	15.	39.3	18.6	36.	23.5	54.15	53.6
94.	9.5	72.2	10.	60.3	10.4	52.2	12.6	45.3	15.	40.5	17.5	36.7	22.	56.56	56.4
94.5	10.	73.	10.3	60.5	11.5	52.	13.	45.5	15.	41.	18.	36.5	23.	56.26	55.7
92.	9.5	73.5	10.	60.5	11.	52.5	12.5	45.5	14.2	40 5	18.	38.	22.	56.96	57.2
93.3	9.9	72.	10.	60.	11.5	51.5	13.	45.2	15.	40.5	17.3	37.	23.	55.16	55.5
90.	9.5	70.5	10.2	59.	12.	50.	13.	43.5	15.	39.	18.	35.5	23.5	53.13	53.2
90.5	9.	70.5	10.5	59.	11.5	51.	12.8	44.	15.	40.	18.	36.5	23.5	54.88	54.8
86.5	10.2	69.	12.	57.5	12.5	49.	13.	43.	15.2	38.5	18.5	35.	23.	53.01	52.8
93.	10.2	73.	11.	60.5	12.	52.	13.5	45.5	15.5	41.	19.	37.2	24.	56.45	56.8
91.1	10.2	70.98	10.71	59.9	11.4	50.5	12.9	44.1	14.8	39.7	18.0	36.4	23.0	55.14	55.01
87.6	9.1	68.5	10.0	57.1	10.9	49.5	12.5	43.3	14.1	39.2	17.6	35.5	22.1	54.34	54.8
90.5	9.0	70.9	9.9	58.9	10.5	50.4	12.8	44.1	14 4	40.0	17.1	36.0	22.8	56.00	55.6
89.7	9.2	69.0	10.2	57.5	11.1	49.5	12.5	43.0	14.6	38.1	17.6	35.1	22.5	52.97	53.6
90.5	10.0	72.0	11.0	60.1	12.2	51.4	14.0	45.3	16.2	40.5	19.2	37.0	24.2	53.44	53.6
90.0	10.5	71.8	11.1	60.1	12.5	51.0	14.6	44.2	16.2	40.0	19.5	36.4	24.0	53.48	53.6
91.5	9.0	72.0	10.0	61.4	11.0	52.1	12.5	46.0	15.0	41.0	17.5	37.2	22.2	57.92	58.4
92.0	8.2	73.0	9.2	60.5	10.1	52.0	12.0	46.1	14.3	40.6	17.2	37.2	21.8	56.77	56.8
93.0	9.1	72.8	10.0	60.2	11.1	52.1	13.1	45.1	15.6	40.5	18.2	36.8	23.0	56.48	56.8
90.0	10.0	72.0	10.5	60.1	11.4	51.6	13.2	45.1	15.8	41.0	18.8	37.2	23.8	56.68	56.8
94.0	9.0	73.1	9.8	60.5	11.5	52.2	13.0	45.5	15.2	41.1	18.8	37.8	23.2	56.71	56.8
95.1	9.0	74.1	10.0	61.2	11.6	52.4	12.8	45.8	14.8	41.0	18.1	37.4	23.3	57.47	58.0
95.0	9.7	73.2	10.1	61.1	11.5	52.4	12.9	45.9	15.0	41.2	18.2	37.5	22.8	57.18	57.2
89.2	9 0	69.0	10.0	57.8	11.0	49.1	14.7	43.1	14.7	38.2	18.0	35.0	22.8	53.94	54.4
92.1	9.0	71.2	10.0	60.0	11.1	51.3	12.5	45.0	14.7	40.2	17.8	36.8	22.1	56.44	56.4
91.5	9.2	71.4	10.2	59.4	11.3	51.1	13.0	44.5	14.7	40.0	18.0	36.3	22.8	56.23	56.8
91.6	9.0	72.8	9.9	60.0	11.0	51.4	12.2	45.0	14.7	40.4	17.2	36.8	22.2	57.20	57.6
88.4	9.0	69.8	10.0	57.6	11.0	49.5	12.2	43.1	14.2	38.9	17.4	35.4	22.4	55.05	55.2
92.6	9.0	72.5	9.5	60.0	11.0	51.5	12.3	45.6	14.6	41.0	17.8	37.1	22.8	55.71	56.0
90.9	9.0	71.3	9.2	54.0	10.6	50.8	11.9	44.2	13.0	39.8	17.0	35.1	21.4	56.04	56.4
90.0	9.0	70.5	10.0	58.8	10.5	50.0	12.1	44.0	14.6	39.8	17.8	36.0	22.6	54.25	54.4
87.8	9.0	69.1	9.0	58.3	10.2	50.0	11.8	43.4	14.3	40.0	17.6	36.0	22.0	56.09	56.0
88.3	9.8	70.0	10.4	57.8	11.2	49.7	12.8	43.0	14.6	39.0	17.8	35.5	22.0	54.45	55.2
90.89	9.22	71.36	10.0	59.2	10.19	50.95	12.79	44.56	14.79	40.06	17.91	36.41	22.67	55.67	55.90

TABLE

ENGINE B—BOTTOM OF

Date.	Time.	Forward Stroke.		Backward Stroke.		At 0 05.		At 0.15.		At 0.25.		At 0.35.	
		Initial.	Final.	Initial.	Final.	+	—	+	—	+	—	+	—
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
May 2...	8 A. M.	28.8	4.5	3.	7.	22.4	2.8	17.2	1.8	14.2	1.8	12.	1.8
"	9 "	27.3	5.	3.5	6.	21.7	2.5	17.	2.	14.1	2.	12.2	2.
"	10 "	28.	5.	3.5	9.	21.9	2.5	17.2	1.9	14.3	1.9	12.3	2.
"	11 "	28.	5.5	4.	9.5	22.5	2.9	17.6	2.	14.6	2.	12.6	2.
"	12 M.	28.	5.6	3.5	8.5	22.4	3.1	16.6	2.	14.6	2.	12.7	2.
"	1 P. M.	27.5	5.6	3.0	8.5	22.1	3.0	17.1	1.9	14.1	1.9	12.	1.9
"	2 "	28.1	5.6	3.5	8.8	22.1	3.1	17.	2.	14.1	2.	12.	2.
"	3 "	27.7	5.8	3.9	9.0	21.9	2.7	17.2	2.	14.6	2.	12.5	2.
"	4 "	27.5	5.6	3.7	8.9	22.5	2.6	17.6	1.9	14.6	2.	12.6	2.
"	5 "	28.5	5.1	3.1	8.1	21.8	2.4	16.9	2.	14.2	2.	12.	2.
"	6 "	28.2	5.8	3.8	8.	21.8	2.9	17.	1.8	13.9	1.9	11.9	2.
"	7 "	28.7	5.5	3.5	7.8	22.1	2.8	17.	1.6	13.9	1.7	11.7	1.7
"	8 "	28.5	5.5	3.5	7.5	22.1	3.	17.	1.8	13.9	1.8	11.9	1.9
"	9 "	28.1	5.5	3.5	8.1	22.	2.2	17.	1.7	14.	1.8	12.	1.8
"	10 "	29.5	5.9	3.4	8.2	22.	2.5	17.1	1.8	14.	1.8	12.	1.8
"	11 "	28.2	5.8	3.2	8.9	22.5	3.	17.	1.6	14.2	1.7	12.	1.8
"	12 "	28.3	5.	3.	8.5	21.	2.6	16.6	1.7	13.6	1.7	11.7	1.8
Average.	.....	28.4	5.42	3.44	8.25	22.04	2.74	17.11	1.85	14.17	1.88	12.12	1.9
May 3...	3 A. M.	28.5	4.5	4.	9.4	21.3	2.6	16.9	1.6	13.9	1.6	11.7	1.6
"	4 "	28.5	5.	4.	8.7	22.0	3.0	16.9	1.7	14.2	1.6	12.0	1.8
"	5 "	28.1	5.	4.	8.9	22.0	3.0	17.0	1.7	14.4	1.6	12.1	1.6
"	6 "	28.	5.2	4.	9.2	22.5	2.8	17.3	1.9	14.8	2.0	12.3	2.0
"	7 "	25.8	4.5	4.	8.	21.2	3.0	16.5	2.0	13.8	2.0	11.6	2.0
"	8 "	26.2	5.	3.5	8.	21.3	2.6	16.9	2.9	14.0	2.0	11.9	2.0
"	9 "	28.0	6.	3.8	7.5	21.8	3.0	16.0	1.9	14.0	2.0	12.0	2.0
"	10 "	28.8	5.5	3.8	8.5	23.1	3.1	18.2	2.1	15.0	2.2	13.0	2.2
"	11 "	27.9	5.	4.	7.5	22.0	2.4	17.3	2.0	14.3	2.0	12.2	2.0
"	12 M.	28.1	5.5	5.	6.9	22.3	2.0	17.8	1.8	14.6	2.0	12.3	1.9
"	1 P. M.	28.5	5.7	5.	7.5	21.8	3.0	17.4	1.9	14.2	1.9	12.0	2.0
"	2 "	28.	5.	4.	7.	22.0	3.2	16.9	2.1	14.0	2.1	12.0	2.1
"	3 "	28.	5.5	4.	8.5	22.5	2.6	17.3	2.0	14.8	2.0	12.4	2.0
"	4 "	29.5	5.	4.	7.7	22.1	3.0	17.3	1.9	14.3	1.9	12.1	2.0
"	5 "	28.5	5.5	3.5	7.2	22.2	3.2	17.2	2.0	14.1	2.0	12.0	2.0
"	6 "	28.4	5.	4.	7.2	21.8	3.2	16.7	1.9	13.8	2.0	11.8	2.0
"	7 "	27.8	5.7	3.5	7.6	21.8	2.8	17.5	1.9	14.2	1.9	12.2	1.9
May 4...	5 A. M.	28.1	7.2	5.1	3.9	22.3	3.4	17.1	2.0	14.2	2.0	12.1	2.0
"	6 "	27.5	7.4	5.	3.6	22.0	3.4	18.9	2.0	14.0	2.0	12.0	2.0
"	7 "	28.	7.9	5.	3.9	22.1	2.4	17.3	1.8	14.4	1.8	12.2	1.8
"	8 "	27.9	7.6	4.8	3.8	22.1	3.4	17.0	2.0	14.0	1.9	12.1	2.0
"	9 "	27.8	7.5	5.	3.8	22.0	3.1	16.8	2.0	13.6	2.0	12.0	2.0
"	10 "	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
"	11 "	28.1	7.	4.9	3.7	22.0	2.8	17.3	2.0	14.3	2.0	12.2	2.0
"	12 M.	28.	7.	4.5	4.	22.1	2.9	17.2	2.0	14.0	2.0	12.0	2.0
"	1 P. M.	27.9	7.5	5.1	3.7	22.2	3.6	17.0	2.0	13.1	2.0	12.1	2.1
"	2 "	27.6	8.0	5.6	3.8	22.4	3.0	17.6	2.0	14.4	2.0	12.3	2.0
Average.	.....	28.00	5.98	4.35	.....	22.03	2.94	17.20	1.96	14.17	1.94	12.10	1.91

No. IV.

LOW-PRESSURE CYLINDER.

At 0.45.		At 0.55.		At 0.65.		At 0.75.		At 0.85.		At 0.95.		Net Average.	Planimeter.
+	—	+	—	+	—	+	—	+	—	+	—		
13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.
10.7	2.	9.7	2.	8.9	2.1	8.2	2.2	7.8	2.3	7.	2.5	9.69	9.48
10.7	2.1	10.	2.2	9.	2.3	8.4	2.4	8.	2.5	7.2	2.7	9.34	9.48
11.	2.	10.1	2.1	9.3	2.3	8.7	2.4	8.	2.4	7.2	2.6	9.69	9.72
11.1	2.	10.1	2.1	9.3	2.2	8.8	2.4	8.1	2.6	7.4	2.8	9.91	9.84
11.1	2.	10.1	2.1	9.4	2.3	8.7	2.3	8.	2.4	7.3	2.9	9 88	9.72
10.5	1.9	9.6	2.1	8.9	2.1	8.1	2.2	7.6	2.4	7.	2.7	9.48	9.48
10.7	2.1	9.6	2.3	8.9	2.4	8.2	2.5	7.8	2.7	7.1	2.9	9.36	9.12
11.1	2.	10.1	2.2	9.3	2.3	8.6	2.4	8.1	2.6	7.3	2.7	9.79	9.72
11.1	2.	10.1	2.1	9.3	2.2	8.6	2.2	8.	2.3	7.3	2.8	9.97	9.72
10.6	2.1	9.6	2.	9.	2.3	8.3	2.4	7.9	2.5	7.2	2.7	9.53	9.48
10.4	2.	9.5	2.2	8.9	2.2	8.1	2.3	7.6	2.4	7.	2.8	9.36	9.36
10.3	1.8	9.2	1.9	8.5	2.	8.	2.	7.4	2.2	7.	2.5	9.49	9.36
10.3	1.9	9.3	2.0	8.7	2.	8.	2.	7.5	2.0	7.	2.5	9.48	9.48
11.	1.8	9.5	1.8	8.8	1.8	8.1	1.9	7.5	2.	7.1	2.1	9.81	9.96
10.5	1.9	9.5	2.0	8.8	2.	8.	2.	7.6	2.1	7.	2.2	9.64	9.94
10.7	1.9	9.8	2.	9.	2.	8.2	2.	7.8	2.1	7.1	2.3	9.79	9.84
10.2	1.8	9.5	1.9	8.4	2.	8.	2.	7.3	2.	6.8	2.2	9.36	9.48
10.7	2.07	9.72	2.05	8.97	2.14	8.29	2.22	7.76	2.44	7.06	2.57	9.66	9.59
10.3	1.8	9.5	1.8	8.6	2.0	7.9	2.1	7.3	2.2	6.9	2.4	9.47	9.48
10.6	2.0	9.6	2.2	8.8	2.2	8.2	2.2	7.6	2.4	7.1	2.6	9.52	9.48
10.7	1.9	9.8	1.9	9.0	2.0	8.3	2.0	7.8	2.1	7.0	2.5	9.74	9.72
10.9	2.0	10.0	2.0	9.2	2.0	8.4	2.2	7.9	2.4	7.2	2.9	9.84	9.72
10.4	2.0	9.5	2.1	8.8	2.1	8.1	2.3	7.6	2.6	7.0	2.6	9.18	9.24
10.3	2.0	9.6	2.2	8.8	2.2	8.2	2.4	7.8	2.6	7.0	2.8	9.20	9.36
10.4	2.1	9.6	2.2	8.8	2.2	8.0	2.3	7.6	2.2	7.0	2.8	9.26	9.36
11.4	2.4	10.4	2.5	9.5	2.3	8.9	2.3	8.2	2.7	7.7	3.0	10.11	9.96
10.9	2.1	9.9	2.3	9.0	2.3	8.3	2.4	7.8	2.4	7.1	3.0	9.59	9.60
10.8	1.9	9.9	2.1	8.9	2.2	8.2	2.2	7.7	2.2	7.1	2.9	9.83	9.84
10.8	1.9	9.6	2.0	8.9	2.3	8.1	2.3	7.6	2.3	7.0	3.0	9.45	9.48
10.6	2.2	9.5	2.3	8.9	2.4	8.2	2.4	7.6	2.4	7.0	2.8	9.28	9.24
11.0	2.1	10.0	2.1	9.1	2.3	8.5	2.4	8.0	2.6	7.2	2.9	9.79	9.72
10.6	1.9	9.5	2.1	8.9	2.2	8.1	2.2	7.6	2.2	7.0	2.8	9.51	9.60
10.6	2.0	9.6	2.1	8.8	2.2	8.1	2.2	7.7	2.2	7.0	2.5	9.48	9.48
10.4	2.1	9.5	2.1	8.6	2.3	8.0	2.3	7.5	2.3	6.9	2.8	9.21	9.36
10.9	1.9	9.9	2.0	9.0	2.2	8.3	2.3	7.9	2.4	7.2	2.8	9.70	9.84
10.8	2.0	9.7	2.1	8.9	2.2	8.1	2.2	7.6	2.4	7.0	2.8	9.46	9.48
10.4	2.0	9.5	2.2	8.8	2.2	8.1	2.3	7.6	2.4	7.0	2.8	9.50	9.12
10.9	1.8	10.0	2.0	9.0	2.0	8.2	2.1	7.8	2.2	7.2	2 8	9.84	9.84
10.7	2.0	9.6	2.0	8.9	2.1	8.1	2.3	7.6	2.4	7.0	2.8	9.42	9.36
10.5	2.0	9.4	2.1	8.8	2.3	8.1	2.4	7.6	2.6	7.0	2.8	9.25	9.12
10.8	2.0	9.5	2.0	8.8	2.3	8.1	2.3	7.6	2.4	7.0	2.7	9.53	9.36
10.6	2.0	9.6	2.1	8.8	2.3	8.0	2.3	7.6	2.4	7.0	2.8	9.41	9.60
10.6	2.0	9.4	2.1	8.9	2.4	8.1	2.4	7.5	2.6	7.0	2.9	9.18	9.24
11.0	2.1	9.7	2.1	9.0	2.3	8.2	2.3	7.8	2.3	7.1	2.8	9.68	9.60
10.69	2.01	9.68	2.10	8.91	2.21	8.19	2.31	7.69	2.38	7.07	2.78	9.51	9.50

TABLE

Date.	Time.	Counter.	High-Pressure Cylinder.		Low-Pressure Cylinder.		Gauge on Main in lbs.
			Top.	Bottom.	Top.	Bottom.	
		1.	2.	3.	4.	5.	6.
May 2	2 A. M.	21026	.....	.....	.....	.....	64.7
"	3 "	22015	.....	.....	.....	.....	64.7
"	4 "	22983	.....	.....	.....	.....	63.7
"	5 "	23961	.....	.....	.....	.....	64.7
"	6 "	24940	.....	.....	.....	.....	64.7
"	7 "	25912	.....	.....	.....	.....	64.2
"	8 "	26872	51.60	55.20	11.04	9.48	64.7
"	9 "	27835	52.00	56.40	11.40	9.48	64.7
"	10 "	28803	51.60	54.80	10.68	9.72	64.7
"	11 "	29771	52.40	52.80	10.32	9.84	64.3
"	12 "	30745	52.00	55.20	10.80	9.72	64.7
"	1 P. M.	31713	52.40	54.40	10.92	9.48	64.5
"	2 "	32685	52.00	56.00	11.04	9.12	64.7
"	3 "	33665	51.20	54.40	10.68	9.72	64.4
"	4 "	34641	52.40	53.60	10.80	9.72	64.2
"	5 "	35618	51.60	56.40	10.68	9.48	64.7
"	6 "	36589	52.00	55.72	11.07	9.36	64.7
"	7 "	37561	51.60	57.20	11.04	9.36	64.7
"	8 "	38541	52.00	55.52	10.68	9.48	64.7
"	9 "	39524	50.40	53.20	10.68	9.96	64.7
"	10 "	40507	50.80	54.80	10.91	9.84	64.7
"	11 "	41487	50.40	52.80	10.44	9.84	64.7
"	12 "	42470	51.60	56.80	10.80	9.48	64.7
Averages and Totals.	.....	.....	51.65	55.01	10.82	9.59	.....
May 3	3 A. M.	43848	51.60	54.80	10.81	9.48	64.7
"	4 "	44823	51.20	55.60	11.04	9.48	64.7
"	5 "	45800	51.20	53.60	10.68	9.72	64.7
"	6 "	46783	50.00	53.60	10.92	9.72	64.7
"	7 "	47753	50.40	53.60	10.80	9.24	64.7
"	8 "	48731	53.20	58.40	11.04	9.36	64.7
"	9 "	49710	52.40	56.80	11.16	9.36	64.7
"	10 "	50679	52.80	56.80	10.80	9.96	64.7
"	11 "	51660	52.40	56.80	11.28	9.60	64.7
"	12 "	52644	52.40	56.80	11.28	9.84	64.7
"	1 P. M.	53616	52.00	58.00	11.28	9.48	64.2
"	2 "	54590	52.80	57.20	11.04	9.24	64.7
"	3 "	55573	53.20	54.40	10.56	9.72	64.7
"	4 "	56554	52.80	56.40	10.20	9.60	64.7
"	5 "	57535	52.80	56.80	10.80	9.48	63.7
"	6 "	58520	52.00	57.60	11.16	9.36	64.2
"	7 "	59502	51.60	55.20	11.28	9.84	64.2
"	8 "	60486	.....	.....	.....	.....	64.2
"	9 "	61472	51.20	55.60	11.40	9.66	64.2
"	10 "	62486	50.80	56.28	10.80	9.46	64.7
"	11 "	63399	50.80	54.16	10.68	9.84	64.7
"	12 "	64371	50.86	54.72	10.20	9.84	64.2
May 4	1 A. M.	65350	51.20	53.68	10.92	9.72	64.2
"	2 "	66327	51.60	54.80	11.16	9.60	64.2
"	3 "	67311	52.40	55.56	10.68	9.36	64.2
"	4 "	68292	52.60	56.40	10.78	9.10	64.2

No. V.

Water in Well below Gauge in lbs.	Total in lbs., + (1 lb. added).	Coal in Furnaces, lbs.	Water fed into Boilers, lbs.	Level of Water in Boilers in inches.	Temperature of Feed Water, Deg. Fahr.	Pressure in Boilers in lbs.	Discharge into Reservoir in gallons.	Lift from Well into Reservoir.
7.	8.	9.	10.	11.	12.	13.	14.	15.
10.15	75.85	279	3250	6.1	94°	89	.....	167.92
10.15	75.85	608	5650	6.6	98°	90	205467	167.92
10.15	74.85	890	7900	6.4	97°	85	203329	167.92
10.15	75.85	1255	10850	6.4	97	91.5	205595	167.92
10.32	76.02	1605	14500	6.1	98	90	207345	168.32
10.52	75.72	2031	17720	7.6	98	90	205416	168.77
10.54	76.24	2495	19320	6.4	96	91.5	204464	168.82
10.55	76.25	2786	22280	6.5	97	92	203279	168.85
10.50	76.20	2934	25150	6.6	98	88.5	203629	168.75
10.50	75.80	3335	29120	7.0	98	88.5	204410	168.73
10.48	76.18	3630	30800	6.5	97	90	205321	168.70
10.44	75.94	3925	33570	6.8	97.5	90	204626	168.64
10.52	76.22	4233	36010	6.7	100.00	90	205003	168.77
10.51	75.91	4559	38710	6.2	99	94	206080	168.75
10.55	75.75	4882	43500	6.6	98	89.5	206188	168.79
10.55	76.25	5170	46260	6.5	100.00	93.5	205999	168.80
10.54	76.24	5491	47500	6.6	100.00	85.5	205622	168.82
10.41	76.11	5792	50700	7.0	100.00	90.0	205730	168.62
10.32	76.02	6124	52550	6.4	100.00	88.0	207615	168.32
10.28	75.98	6518	55200	7.1	101.00	90	208396	168.22
10.24	75.94	6811	59100	7.0	100.00	90	207349	168.12
10.24	75.94	7215	61250	6.3	99	89	207494	168.12
10.24	75.94	7545	64100	6.6	99	90	208983	168.12
.....	75.96	7266	60850	....	.....	.....	4527340	168.48
10.28	75.98	124	68100	7.2	92	90	.....	168.22
10.37	76.07	412	70050	6.9	93	70	206379	168.42
10.37	76.07	688	72450	6.8	97	90	205457	168.42
10.45	76.15	980	75450	6.9	98	87	208306	168.62
10.54	76.24	1305	77400	6.2	98	84	206514	168.82
10.57	76.27	1805	80020	6.1	99	93.5	207076	168.90
10.57	76.27	1989	83450	6.4	101	85	208153	168.91
10.59	76.29	2413	85820	6.9	101	88.5	204855	168.95
10.64	76.34	2814	89710	7.1	101	90.4	207749	168.99
10.64	76.34	3020	91550	6.2	100	88.5	208826	169.00
10.58	75.78	3380	94470	6.6	101	84	206538	168.92
10.65	76.35	3804	97950	6.7	101	90	206538	169.06
10.65	76.35	4182	100050	6.9	101	89	207076	169.06
10.65	76.35	4608	103800	7.1	101	85.5	207076	169.07
10.65	75.35	5021	107900	8.1	102.5	93.5	207480	169.06
10.66	75.86	5288	108650	6.5	98.0	93.5	208692	169.09
10.56	75.76	5574	111000	5.9	100.5	89.0	208557	168.87
10.56	75.76	5916	114400	6.7	100.5	90	208826	168.86
10.55	75.75	6192	116990	6.8	100.00	90	208961	168.83
10.53	76.23	6498	119800	6.6	100.05	85	204699	168.80
10.53	76.23	6825	122610	7.2	100	88	204284	168.79
10.53	75.73	7136	124980	6.5	100	86	207749	168.79
10.53	75.73	7430	127850	6 9	100	87	207501	168.79
10.53	75.73	7758	130470	6.8	100	89	207455	168.80
10.53	75.73	8080	134000	7.0	100.5	87	210844	168.81
10.53	75.73	8516	138710	7.4	100	90	208360	168.80

TABLE

Date.	Time.	Counter.	High-Pressure Cylinder.		Low-Pressure Cylinder.		Gauge on Main in lbs.
			Top.	Bottom.	Top.	Bottom.	
		1.	2.	3.	4.	5.	6.
May 4	5 A. M.	69273	52.40	56.00	11.16	9.48	64.2
"	6 "	70257	52.00	55.48	10.80	9.12	64.2
"	7 "	71236	51.20	53.72	10.56	9.84	64.2
"	8 "	72210	51.60	57.40	10.56	9.36	64.2
"	9 "	73186	51.60	55.71	10.68	9.12	64.2
"	10 "	74159	.....	.....	.....	.....	64.2
"	11 "	75137	52.40	56.040	10.68	9.36	64.2
"	12 "	76113	52.00	54.40	10.92	9.60	64.2
"	1 P. M.	77086	53.20	56.00	10.68	9.24	64.7
"	2 "	78066	51.60	55.20	10.68	9.60	64.7
Averages and Totals.	.....	.....	51.88	55.69	10.86	9.60	.....
May 5	8 A. M.	79892	.....	.....	.....	.....	62.7
"	9 "	60687	.....	.....	.....	.....	63.7
"	10 "	81459	.....	.....	.....	.....	64.7
"	11 "	82208	.....	.....	.....	.....	65.7
"	12 "	82972	.....	.....	.....	.....	65.7
"	1 P. M.	83670	.....	.....	.....	.....	65.7
"	2 "	84423	.....	.....	.....	.....	67.2
"	3 "	85225	.....	.....	.....	.....	66.7
"	4 "	86028	.....	.....	.....	.....	66.7
"	5 "	86801	.....	.....	.....	.....	66.7
"	6 "	87661	.....	.....	.....	.....	66.7
"	7 "	88536	.....	.....	.....	.....	66.7
"	8 "	89395	.....	.....	.....	.....	66.7
"	9 "	90238	.....	.....	.....	.....	66.7
"	10 "	91004	.....	.....	.....	.....	66.7
"	11 "	91838	.....	.....	.....	.....	66.7
"	12 "	92714	.....	.....	.....	.....	66.7
May 6	1 A. M.	93525	.....	.....	.....	.....	65.7
"	2 "	94341	.....	.....	.....	.....	65.7
"	3 "	95146	.....	.....	.....	.....	66.7
"	4 "	95993	.....	.....	.....	.....	64.7
"	5 "	96740	.....	.....	.....	.....	65.7
"	6 "	97531	.....	.....	.....	.....	65.7
"	7 "	98347	.....	.....	.....	.....	64.7
"	8 "	99069	.....	.....	.....	.....	66.7
"	9 "	99886	.....	.....	.....	.....	66.7
"	10 "	100707	.....	.....	.....	.....	65.7
"	11 "	101519	.....	.....	.....	.....	65.7
"	12 "	102339	.....	.....	.....	.....	65.7
"	1 P. M.	103137	.....	.....	.....	.....	66.2
"	2 "	103948	.....	.....	.....	.....	66.2
"	3 "	104737	.....	.....	.....	.....	66.2
"	4 "	105534	.....	.....	.....	.....	66.2
"	5 "	106316	.....	.....	.....	.....	65.7
"	6 "	107140	.....	.....	.....	.....	66.2
Averages and Totals.	.....	.....	.....	.....	.....	.....	.....

* The last two discharges at 5 and 6 were calculated from the average discharge

No. V.—(*Continued.*)

Water in Well below Gauge in lbs.	Total in lbs., + (1 lb. added).	Coal in Furnaces, lbs.	Water fed into Boilers, lbs.	Level of Water in Boilers in inches.	Temperature of Feed Water, Deg. Fahr.	Pressure in Boilers in lbs.	Discharge into Reservoir in gallons.	Lift from Well into Reservoir.
7.	8.	9.	10.	11.	12.	13.	14.	15.
10.53	75.73	8815	140460	7.9	101	87	208184	168.81
10.53	75.73	9075	141770	6.6	100	90	209634	168.81
10.63	75.83	9394	144420	6.2	101	89	207345	169.02
10.61	75.81	9735	146700	6.0	99	89	206888	169.07
10.61	75.81	10031	149850	6.5	101	89	206597	169.07
10.61	75.81	10378	152325	6.0	101	92	207480	169.07
10.72	75.92	10697	155050	6.4	100	90	208692	169.22
10.68	75.88	11000	157800	5.7	101	90	206805	169.15
10.64	75.34	11429	160540	5.2	101	95	207480	169.03
10.70	76.40	11754	163200	5.7	104	90	208153	169.18
.....	75.79	11630	95100	.....	.....	.....	7261209	168.91
10.78	74.48	473	1970	5.7	87	90	.....	169.66
10.78	75.48	1000	7975	6.2	101	89	335384	169.65
10.80	76.50	1471	13475	6.5	97	90	329941	169.72
10.81	77.51	2000	17050	6.6	99	90.5	318519	169.74
10.77	77.47	2485	21375	6.2	107	94	327761	169.65
10.81	77.51	3000	28625	6.0	108	91	297886	169.75
10.82	79.02	3526	29800	6.2	101	90	321192	169.77
10.83	78.53	4000	34800	5.6	100	89	337239	169.80
10.81	78.51	4502	39540	6.1	95.5	90	338345	169.75
10.85	78.55	4970	43590	6.2	96	90	324129	169.85
10.85	78.55	5550	48860	6.0	105	89	362305	169.85
10.77	78.47	6000	54200	6.1	106	91	362774	169.65
10.78	78.48	6519	59360	6.9	105	90	358912	169.67
10.75	78.45	7111	64430	6.5	102	88	351500	169.61
10.72	78.42	7664	69160	7.0	100	90	318399	169.52
10.75	78.45	8350	74620	7.2	101	91	344947	169.60
10.75	78.45	8967	79800	7.5	104	91	364913	169.59
10.74	77.44	9500	84100	7.0	101	90	338488	169.56
10.74	77.44	10000	88750	6.7	101	92	337277	169.56
10.75	78.45	10650	94250	7.5	102	90	332581	169.61
10.70	76.40	11192	98750	6.8	103	89	356208	169.47
10.67	77.37	11715	103200	7.0	96	92	311852	169.43
10.75	77.45	12302	108300	6.7	101	89	325778	169.59
10.75	76.45	12846	113200	6.8	100	90	341304	169.60
10.83	78.53	13556	116825	6.7	96	90	308958	169.79
10.82	78.52	14000	121675	6.2	98	95	348088	169.76
10.84	77.54	14463	126700	5.7	100	90	345970	169.82
10.85	77.55	15000	130900	6.1	102	92	342933	169.84
10.85	77.55	15505	133990	6.2	100	93	347924	169.85
10.87	78.07	16000	138800	6.4	100	93	338324	169.88
10.82	78.02	16627	143540	6.3	100	94	338365	169.77
10.73	77.93	17000	148040	6.2	100	90	332933	169.54
10.72	77.92	17546	153150	6.1	98	93	334575	169.51
10.67	77.37	18165	158100	6.3	97	89	328620*	169.42
10.68	77.88	18884	163300	6.4	102	94	346269	169.45
.....	77.73	18411	161330	.....	.....	.....	11450593	169.66

per revolution in the preceding 32 hours, and not from observations of the Weir.

TABLE

Date.	Time.	Gauges.				Temperatures.		
		At Engine.		Boilers.		Steam-pipe, D. Fahr.	High-Pressure Cylinder Jacket.	Low-Pressure Cylinder Jacket.
		Steam.	Vacuum.	No. 1.	No. 2.			
		1.	2.	3.	4.	5.	6.	7.
May 2....	2 A. M.	88	27.2	89	89	328	.....	.....
"	3 "	90	27.2	90	90	329	.....	.....
"	4 "	85	27.2	85	85	326	.....	.....
"	5 "	92	27.0	92	91	330	.....	.....
"	6 "	92	27.2	90	90	330	.....	.....
"	7 "	88	27.2	90	90	329	.....	.....
"	8 "	92	27.2	92	91	330	.....	.....
"	9 "	92	27.1	92	92	330	.....	.....
"	10 "	88	27.2	88	89	329	.....	.....
"	11 "	87	27.3	88	89	327.5	327.5	324.5
"	12 "	86	27.1	90	90	330.5	331	327
"	1 P. M.	90	27.2	90	90	330	330	327
"	2 "	89	27.2	90	90	329.5	330	326.5
"	3 "	92	27.3	94	94	330	329.5	327
"	4 "	89	27.3	89	90	329	329.5	326
"	5 "	92	27.3	93	94	331.0	331.5	328
"	6 "	87	27.3	85	86	327	326	323
"	7 "	88	27.2	90	90	328	328	325
"	8 "	88	27.2	88	88	328	328	325
"	9 "	90	27.4	90	90	330	330	327
"	10 "	90	27.3	90	90	330	329	326
"	11 "	88	27.3	88	88	330	330	326
"	12 "	90	27.4	90	90	330	330	326
May 3....	3 A. M.	90	27.4	90	90	330	330	327
"	4 "	89	25.5	90	90	329	329	326
"	5 "	90	27.5	90	90	330	330	327
"	6 "	88	27.4	87	87	328	328	325
"	7 "	83	27.5	84	84	324	324	321
"	8 "	93	27.3	93	94	331.5	332	328
"	9 "	86	27.4	85	85	325	326	322
"	10 "	89	27.3	88	89	327	327	324
"	11 "	90	27.5	94	94	331.5	331.5	328
"	12 "	90	27.4	88	89	328	328	324
"	1 P. M.	83	27.3	84	84	325	326	322
"	2 "	89	27.3	90	90	330	331	328
"	3 "	87	27.2	89	89	327	328	324
"	4 "	87	27.0	85	86	326	328	325
"	5 "	93	27.2	94	93	331	331	328
"	6 "	93	27.2	93	94	331	331	328
"	7 "	89	27.2	89	89	328	328	325
"	8 "	80	27.3	90	90	330	330	328
"	9 "	88	27.3	90	90	330	330	326
"	10 "	84	27.5	85	85	326.5	326	324
"	11 "	87	27.4	88	88	328	328.5	324.5
"	12 "	86	27.4	86	86	326	327	323
May 4....	1 A. M.	88	27.4	87	87	327.5	328	323
"	2 "	88	27.4	89	89	328	329	326

No. VI.

Temperatures.				Hygrometer.			Barometer.	
In Flues.	Outside Atmosphere.	Boiler-House.	Water in Pump-Well.	Wet Bulb.	Dry Bulb.	Humid.	Thermometer attached.	Barometer.
8.	9.	10.	11.	12.	13.	14.	15.	16.
210	44	66	.....	58.5	62.5	77	51.5	29.63
260	44	66	45	58	63	72	51	29.65
274	43	67	45	59	63	77	51	29.65
280	42	66	45	58	63	72	51	29.70
240	43.5	67	.....	59	64	72	54	29.70
236	45.5	67	.....	60	64	78	52	29.75
247	48	66	45	59	64	72	53	29.76
257	49.8	68	45	59	64	72	53	29.76
248	52.2	66	45	60	65.5	73	52.5	29.77
267	53.5	68	45	60.5	66.5	68	53.8	29.81
252	55.2	68	45.5	60	67	64	55	29.81
254	56.0	68	46.0	60	67	64	56	29.84
250	57 5	68	46.0	59	67	59	57	29.83
245	58.8	68	46.5	60	69	56	57	29.84
244	58.5	68	47.0	61	69	60.5	57	29.86
254	54.5	72	47.0	62	69	65	54	29.88
278	54 0	72	47.0	62	68.5	69	53	29.90
290	50.5	72	46.0	61	68	64	52	29.92
300	49.0	72	46.0	63	69	69	51	29.90
310	48.0	74	46.0	63	69	69	52	29.90
306	48.0	74	46.0	63	69	69	53	29.90
310	47.0	74	46.0	63	69	69	53	29.92
302	47.0	74	46.0	63	69	69	52	29.96
280	45.0	75	46.0	62	68	69	52	29.95
268	44.0	74	46.0	61	68	64	51	29.95
274	44.0	74	46.0	62	68	69	51	29.96
294	44.0	74	46.0	62	68	69	51	29.96
290	46.0	74	.....	62	68	69	51	29.96
310	48.5	.....	46.5	62.5	69.5	65	49.5	29.95
310	50.5	72	47.0	62	69.5	65	50.5	29.97
334	52.0	74	48	63	70	65.5	52	29.98
344	50.0	74	47	60	68	60	56	29.98
308	47.5	.....	48	61	69	60.5	59	30.00
330	47.5	72	47.5	60	69	56	49	30.02
378	47.0	71	45.0	62	70	61	53	30.00
354	44.0	68	45.0	59	68	55	53	30.00
334	42.0	67	45.0	60	68	60	45	30.00
330	41.0	67	46.0	60	68	60	43.5	30.00
302	40.5	72	46.0	60	67.5	64	43	30.01
288	39.0	70	46.0	60	67	64	46	30.01
284	39.4	74	46.0	59	68	59.5	44	30.01
300	39.5	73	46.0	61	68	64.5	48	30.02
308	39.0	73	46.0	61	67.5	66.5	45.5	30.01
310	38.5	72	46.0	61	67 0	68.5	46	29.99
304	37.0	72	46.0	60.5	67.5	64	46.5	30.00
302	36.0	72	46.0	60	67.5	62	45	30.00
292	34.5	72	46.0	60	67	64	47.5	30.01

TABLE

Date.	Time.	Gauges.				Temperatures.		
		At Engine.		Boilers.		Steam-pipe, Deg. Fahr.	High-Pressure Cylinder Jacket.	Low-Pressure Cylinder Jacket.
		Steam.	Vacuum.	No. 1.	No. 2.			
		1.	2.	3.	4.	5.	6.	7.
May 4....	3 A. M.	87	27.4	87	87	328	328	325
"	4 "	88	27.5	90	90	330	330	326
"	5 "	86	27.4	87	87	327	327	324
"	6 "	89	27.5	90	90	329	330	326
"	7 "	87	27.5	89	89	328	329	325
"	8 "	87	27.5	89	89	329	329	326
"	9 "	85	28.5	89	89	329	329	326
"	10 "	93	27.5	92	92	332	331	328
"	11 "	83	27.5	90	90	329	330	327
"	12 "	89	27.3	90	90	328	329	325
"	1 P. M.	92	27.4	95	95	331	331	329
"	2 "	88	27.2	90	90	329	330	326
May 5....	8 A. M.	88	27.6	90	90	329	330	327
"	9 "	87.5	27.2	89	89	331	331	328
"	10 "	89	27.3	90	90	330	330	327
"	11 "	90	27.6	91	90	330	330	326
"	12 "	92	27.5	94	94	330	330	328
"	1 P. M.	91	27.3	91	91	331	330	327
"	2 "	89	27.7	90	90	330	330	326
"	3 "	89	26.9	89	89	328	328	325
"	4 "	90	28.0	90	90	330	329	326
"	5 "	91	27.3	90	90	330	330	327
"	6 "	88	27.3	89	89	328.5	328	325
"	7 "	93	27.3	91	91	331	331	328
"	8 "	91	27.1	90	90	330	330	327
"	9 "	88	27.5	88	88	328	328	325
"	10 "	90	27.7	90	90	329	329	326
"	11 "	92	27.2	91	91	331	330	328
"	12 "	92	27.3	91	91	331.5	330	328
May 6....	1 A. M.	91	27.5	90	90	330	330	328
"	2 "	92	27.5	92	92	331	331	329
"	3 "	90	27.3	90	90	330	331	328
"	4 "	88	28.0	89	89	330	329	326
"	5 "	90	27.7	92	92	331	330	327
"	6 "	87	27.5	89	89	329	330	326
"	7 "	89	27.4	90	90	329	329	326
"	8 "	89	27.4	90	90	330	330	326
"	9 "	94	27.0	95	95	332	332	328
"	10 "	92	27.3	90	90	330	330	326
"	11 "	97	27.2	92	92	332	330	328
"	12 "	93	27.5	93	93	332	331	328
"	1 P. M.	92	27.4	93	93	332	332	328
"	2 "	93	27.6	94	94	332.5	331.5	328
"	3 "	91	27.6	90	90	331	330	327
"	4 "	92	27.4	93	93	330	331	329
"	5 "	86	27.4	89	89	329	329	325
"	6 "	90	27.3	94	94	332	331	329

No. VI.—(*Continued.*)

Temperatures.				Hygrometer.			Barometer.	
In Flues.	Outside Atmosphere.	Boiler-House.	Water in Pump-Well.	Wet Bulb.	Dry Bulb.	Humid.	Thermometer.	Barometer.
8.	9.	10.	11.	12.	13.	14.	15.	16.
280	31.5	72	46.0	60	67	64	45	30.01
296	32	72	45.5	60	67	64	46.5	30.00
274	33.5	72	45.5	60	67	64	46.5	30.01
258	35	72	45.5	60.5	67	66	47	30.02
268	39	72	45.5	61	67	68.5	46	30.05
278	44	72	45.5	61	68	64.5	51	30.05
282	45	73	45.5	62	69	65	50	30.01
300	47.5	74	45.5	63	70	65.5	50.5	30.05
302	50.5	75	45.5	61	69	60.5	51	30.01
324	52.5	75	46.0	63	71	61.5	52	30.09
342	55	76	47.0	64	72	62.0	54	30 09
312	55	77	47.0	63	72	58.5	54.5	30.09
318	48.5	68	48.0	62	69	65.5	51	30.25
345	51.0	71	46.0	63	70	65.5	51	30.25
330	53.0	72	46.0	64	70.5	70	52	30.25
330	52.5	73	46.0	64	70.5	70	52	30.25
330	52.0	73	46.5	64	71	66	52	30.25
320	53.0	74	47	65	72	66	51.5	30.35
340	50.0	70	47	65	71	70.5	51	30.25
370	49.0	74	46.5	64.5	70.5	70	50	30.22
365	48.5	74	47.0	64.5	70.5	70	50	30.24
368	47.5	74	46.5	64	70	70	49	30.24
384	47	74	46.5	64	70	70	48	30.24
390	46	74	46	65	72	66.5	48	30.27
394	45.5	74	46.5	64.5	70.5	70	50	30.25
400	45.0	74	46	64.5	70.5	70	47.5	30.25
404	45.0	74	46	64.5	70.5	70	50	30.24
400	45.0	74	46	65	71	70.5	51	30.25
410	45.0	74	46	65	72	66.5	50	30.26
400	44.5	74	46	66	72	71	46	30.25
420	44	74	46	66	71	75	45	30.22
420	44	74	46	66	72	75	45	30.20
410	43.5	75	46	66	71	75	49	30.21
410	43	75	46	65	71	70.5	48.5	30.20
412	43	74	46	65	71	70.5	50	30.20
350	44	74	46	65	71	70.5	50	30.20
315	45.5	74	46	65	71	70.5	48	30.18
332	47	74	46	66	71.5	75	50	30.16
340	48	74	46	65	70	70.5	49	30.14
335	49	74	46	64.5	70.5	70	50.5	30.10
344	49	74	46	64	70.5	68	49	30.09
342	50.5	72	46	66	71.5	73	50.5	30.07
345	51	74	46	65.5	71	72.5	51	30.03
355	52	72	46	65.5	71	72.5	51.5	30.02
378	54	73	46	66	71	75	53	30.09
390	55.5	72	46	66	72	71	54	30.09
400	55.5	74	46	67	72	75.5	54	30.07

EXPLANATIONS OF TABLES.

In tables I. and III., columns 2 are the points of cut-off of the steam in decimals of the stroke, columns 3 the pressures of steam at the time of cut-off, columns 6 are the points at which compression commences in the exhaust lines in decimals of stroke, and columns 7, the pressures at this point. In all the tables of indicator cards, I., II., III., and IV., the pressures are referred to the zero-line as determined by observations of the barometer referred to the atmospheric line of the indicators. In the last column of all the tables the net average pressures as determined by the planimeter are given.

Table V., columns 2, 3, 4, and 5, are the net average pressures as determined by the planimeter; column 6 is the readings of the gauge on the main corrected by the subtraction of 0.3 pound, the observed difference between this gauge and the standard; column 7 is the difference of level between the gauge and the hourly-observed level in the well, converting feet into pounds by dividing by 2.31; column 8 is the lift in pounds determined by the terms of the contract; column 9 is the totals of coal, and column 10 the totals of water as it was fed upon the grates or into the boiler from hour to hour; column 11 was the hourly-observed level of the water in the boiler, referred to the crown-sheets of the fire-box instead of to the usual standard of a zero of common water level.

Column 14 is the hourly discharge of gallons of water into the reservoir as measured at the weir.

Column 15 is the absolute static heights of the water

over the weir above the level of the water in the pump-well. The crest of the weir and the gauge in the well were referred to the same base, and the column is made up from the hourly observations.

The footings of columns 2, 3, 4, 5, 8, and 15 are averages; of 9, 10, and 14, totals of pounds of coal used, of water fed, and of gallons of water delivered into the reservoir.

By the contract the coal was to be Cumberland, and the kind furnished was supposed to be of a good quality; but, during the progress of the test, the evaporative results not being satisfactory, another lot was substituted, and fired from 5 P. M., May 3d, to 11 A. M., May 6th, with but little improvements in results. The ashes and cinders were weighed—978 pounds in the single engine tests, 435 pounds during the time the engines were coupled.

Table VI. are the observations as taken of the pressure of gauges, temperatures by thermometers, saturation of atmosphere, and pressure by barometer. The caption sufficiently explains the position of the instruments. All the steam gauges were tested by Mr. Moore, of the American Steam Gauge Company; the one on the engine was verified by us, and found to be one pound short in the range from 80 to 95 pounds, so that one pound should be added to the readings in column one.

The thermometer in the flue indicated too low a temperature for the escaping gases, and 4 P. M., May 2d, all air-cracks into the flues were carefully closed.

It was thought advisable that the specific gravity of the water should be tested, which was done by Mr. Maurice Hasenclever, who reports as follows:

Specific gravity of Water as taken from the Engine-house.

Temperature 60° F.

(Compared with distilled water and 60° F. being 1.00000).

Specific gravity = 1.004871

Specific gravity of Reservoir Water Temp. 57° } = 1.005119

The difference of 0.000245 is very near what theory allows for 3° F. expansion.

May 5, 1876.

Observations were made of the flow at the condensed water weir at different times when the water was not directed into the measuring tank for the feeding of the boiler. The results, as given below, are in pounds per second:

May 2...	2.15	to	2.45	A. M.....	10.86	lbs.			
"	4.20	"	4.45	"	11.32	"	at	101°
"	12.8	"	12.31	P. M.....	11.41	"	"	101°
"	2.30	"	2.52	"	11.11	"	"	99°
"	4.	"	4.17	"	10.71	"	"	103°
"	10.7	"	10.31	"	11.16	"	"	
May 3...	4.10	"	5.25	A. M.....	11.45	"	"	
"	10.57	"	11.47	"	10.92	"	"	
"	2.15	"	3.	P. M.....	10.82	"	"	106°
"	3.	"	4.	"	10.59	"	"	109°
"	4.	"	5.	"	10.43	"	"	106°
"	5.	"	6.	"	10.34	"	"	106.5°
"	6.	"	6.45	"	10.39	"	"	106.5°
May 4...	3.40	"	3.50	A. M.....	10.26	"	"	104.5°
"	6.2	"	6.15	"	10.58	"	"	105°
"	9.	"	9.32	"	10.13	"	"	106.5°
"	10.50	"	11.50	"	10.29	"	"	106.75°

CALCULATION FROM THE DATA OBTAINED.—*Duty per pound of coal in the steam cylinders, estimated from the indicator card:*

Diameter of high-pressure cylinders..... 18″ area, 254.47 sq. in.
This will be effective area of bottom of piston ; of the top it will be less the area of piston rod, or
254.47—9.62..... 244.85 "
Diameter of low-pressure cylinder..... 38″ area, 1134.11 "
Top area of piston, 1134.11—12.57..... 1121.54 "

During the 22 hours, from 2 A. M. to 12 P. M., May 2d, the average pressures by planimeter, Table V., were:

Top of high-pressure cylinder..... 51.65
Bottom " " " 55.01
Top of low " " 10.82
Bottom " " " 9.59

Top high-pressure....	51.65 × 244.85 =	12646.5		
Bottom "	55.01 × 254.47 =		13998.4	
Top low-pressure.....	10.82 × 1121.54 =	12135.1		
Bottom "	9.59 × 1134.11 =		10876.1	
		24781.6	24874.5	49656.1

The length of stroke was 8 feet, the number of revolutions, 21,444, and coal consumed, 7,266 pounds.

$$\frac{49656.1 \times 21444 \times 8}{7266} = 1,172,365 \text{ pounds feet per pound of coal;}$$

since 1 H. P. = 1,980,000 pounds feet per hour.

$$\frac{1,980,000}{1,172,365} = 1.69.$$

That is, 1 indicated horse power for every 1.69 pound of coal fed upon the grates.

During the 35 hours, from 3 A. M., May 3d, to 2 P. M., May 4th, the average pressures in the steam cylinders were:

Top of high-pressure cylinder..... 51.88
Bottom " " " 55.69
Top of low " " 10.86
Bottom " " " 9.60

Top high-pressure....	51.88 × 244.85 =	12702.8		
Bottom "	55.69 × 254.47 =		14171.4	
Top low-pressure	10.86 × 1121.54 =	12179.8		
Bottom "	9.6 × 1134.11 =		10887.4	
		24882.6	25058.8	49941.4

The number of revolutions was 34,218; coal consumed, 11,630 pounds.

$$\frac{49941.4 \times 34218 \times 8}{11630} = 1,175,508 \text{ pounds feet per pound of coal;}$$

$$\frac{1.980.000}{1175508} = 1.684 \text{ pounds per hour, per 1 indicated H. P.}$$

In the early part of this report the duty per pound of coal determined by the terms of the contract on the main was:

For the 22 hours..... 962.019 pounds feet.
" 35 " ..... 961.776 " "

During the 34 hours of trial of the engines running coupled, the average pressure was 77.73 pounds; the gallons discharged into the reservoir, 11,450,593; coal consumed, 18,411.

$$1.05 \times \frac{(77.73 \times 2.31) \times (11450593 \times 8.38)}{18411} = 982617 \text{ lbs. ft. per lb. of coal.}$$

Comparison of the static head of the water over the weir above the level of the water in the well, with the head determined according to the terms of the contract.

For 22 hrs.,	May 2,	Static head,	168.48.	Contract,	75.96 × 2.31 = 175.47
" 35 "	" 3 and 4,	" "	168.91	"	75.79 × 2.31 = 175.07
" 34 "	" 5 and 6,	" "	169.66	"	77.73 × 2.31 = 179.56

Comparison of the measured capacity of the pump with the delivery into the reservoir. No measurements of the interior of the pump-barrels were taken by the experts. The measures have been taken from the notes of Mr. Leavitt. Diameter of pump-bucket, 26⅛ inches; area, 536.05; stroke, 96 inches.

$$\frac{536.05 \times 96}{231} = 222.77 \text{ gallons per revolution.}$$

In the 22 hours.... $\frac{4527340 \text{ galls.}}{21444 \text{ revols.}}$ = 211.12 gallons per revolution; .948 of measured capacity.

In the 35 hours.... $\frac{7261209 \text{ galls.}}{34218 \text{ revols.}}$ = 212.2 galls.; .952 measured capacity.

" 34 " .... $\frac{11450593}{27248 \times 2}$ = 210.11 " .943 " "

Evaporation.—The quantities of water measured at the tanks are not exactly the quantities evaporated in the boilers, as it will be observed that the levels of water in the boilers are not the same at the ends of the tests as at the beginning. A correction must therefore be applied.

For the data for this calculation we assume a uniform pressure in the boiler of 90 pounds, 330° of temperature, of feed-water of 100°, of total in steam, 1214°, in all the tests. The cubic contents of each boiler, for the single inch between 6″ and 7″, we estimate at 10 cubic feet, and the weight at 605 pounds. In the 1st and 3d tests the level of water in the boiler at the end of tests was, 5″ and 7″ higher than at the beginning, or there were 605 pounds in one, and 847 pounds in the other, more than at the beginning, which was not evaporated, but had been raised from the temperature of feed-water, 100°, to temperature of water in boiler, 330°; the net deduction we therefore make 480 pounds.

In the 3d test, in the same way, we make the net deduction to be 672 pounds.

In the 2d test, 35 hours, the water in the boiler at the end of the test was 1.5″ lower than in the beginning; 1210×1.5; 1815 pounds had been evaporated, which had not during the test been measured in the tanks. But this water had not been evaporated from the temperature of the feed-water, 100°, but from that of the boiler water, 330°, equivalent to 1440 pounds evaporated from 100°, which should be added to amount given in the table.

The water was weighed into the measuring tank at 45°, and taken from it for the boilers at 100°. The last columns are the pounds of water corrected for this difference in temperatures.

	Coal.	Water from Tanks.	Correction.	Water Evaporated from 100°.		
				Total.	Per Pound of Coal.	Actual Evaporation per Pound of Coal.
1st test 22 hrs.	7,266	60,852	−480	60,370	8.31	8.27
2d " 35 "	11,630	95,100	+1,440	96,540	8.31	8.27
3d " 34 "	18,411	161,330	−672	160,658	8.73	8.69

At the time of the tests, the preparations were not sufficiently complete to measure the water condensed in the jackets, and this was made the subject of an after-examination by Mr. Hoadley, May 23d, using the tank for water of condensation as a measure. Reading by the hook gauge, he found that from 11 A. M. to 5 P. M. the water rose from .0155 foot to 1.7700 or 1.7545 foot, or at the rate of .2924 foot per hour for 6 hours. The area of tank, including

gauge-box, was 19.186 square feet. The mean temperature of water, 188°; weight per cubic foot, 60.4167 pounds.

$$19186 \times .2924 \times 60.4167 = 338.85 \text{ pounds per hour,}$$

as the water condensed in the jackets of the cylinders, engine B.

But exactly the same conditions did not obtain as during the test. The pressure carried in the boilers at this time was from 70 to 75 pounds, and the observed temperature in the low-pressure cylinder jacket at 75 pounds was 315°. At the time of test there was an average of about 326° under 90 pounds pressure.

Coal consumed per Hour per Square Foot of Grate.—During the 1st and 2d tests, of 22 hours and 35 hours, although both boilers were used, the grate surfaces were reduced by a brick bridge on the rear of the bars, which were removed in the 3d test, when the engines ran coupled. The net area of grate surface in the 1st and 2d tests was 47 square feet; in the 3d, $58\frac{3}{4}$ square feet.

Coal Fed per Hour.—

1st test.....	$\frac{7266}{22} = 330.3$	$\frac{330.3}{47} = 7.03$	pounds per square foot of grate.
2d "	$\frac{11630}{35} = 332.3$	$\frac{332.3}{47} = 7.07$	" " "
3d "	$\frac{18411}{34} = 541.5$	$\frac{541.5}{58.75} = 9.22$	" " "

Comparison of curves as given by the indicator with theoretical, adiabatic, and isothermal curves. A set of indicator cards, from both ends of both cylinders, were very carefully divided and measured by Mr. Hoadley, of our Board, and replotted, the low-pressure cylinder at bottom, in connection with high-pressure bottom, and the low-press-

ure top with high-pressure top, all volumes being represented in the terms of volumes of high-pressure cylinder. On these cards, thus constructed, isothermal and adiabatic curves and lines of temperatures are plotted. The indicator cards and comparative cards are given in the accompanying figures, with the tables of volumes, temperatures, and pressures, on which the comparative cards were constructed, and which will be sufficiently explanatory of each other.

In conclusion, it has been our aim to give as fully as possible all the data acquired and facts arrived at, with such deductions as were necessary by the terms of the contract, or explanatory of the working of the engine, and readily comparative with the results of others. With regard to material and workmanship, the engines are strong, compact, well made, and, in disposition of material, good examples of mechanical engineering, and in their future working we feel sure that they will be serviceable and economical, and that the duty now arrived at could be readily surpassed after longer working and acquaintance with the machines and their appliances.

Yours, respectfully,

(Signed) W. E. WORTHEN.
J. C. HOADLEY.
JOS. P. DAVIS.

LAWRENCE WATER WORKS

May 4, 1876.

INDICATOR DIAGRAMS, LOWER END.

High-pressure cylinder, 18 in. diameter, 96 in. stroke. Volu
14.13715 cubic ft. Clearance, 564 cubic in. = 2.31 per cent.

Low-pressure cylinder, 38 in. diameter, 96 in. stroke. Volu
63.0058 cubic ft. Clearance, 1977 cubic in. = 1.82 per cent.

Difference of volume of cylinders, 108874 — 24429 = 84445 c

Clearance of low-pressure cylinder, and difference of volume
in terms of volume of high-pressure cylinder, as follows:

1977 ÷ 24429 = .080928 = 8.09 per cent.

84445 ÷ 24429 = 3.4567.

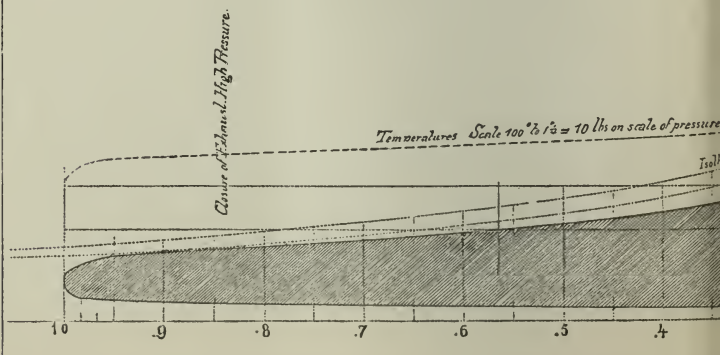
Isothermal curve, $p \propto v$

Adiabatic curve, $p \propto v^{\frac{17}{16}}$

Barometer, corrected 30.099 in. = 14.78 lbs. per squa

I axis of Isothermal curve.

A axis of Adiabatic curve.



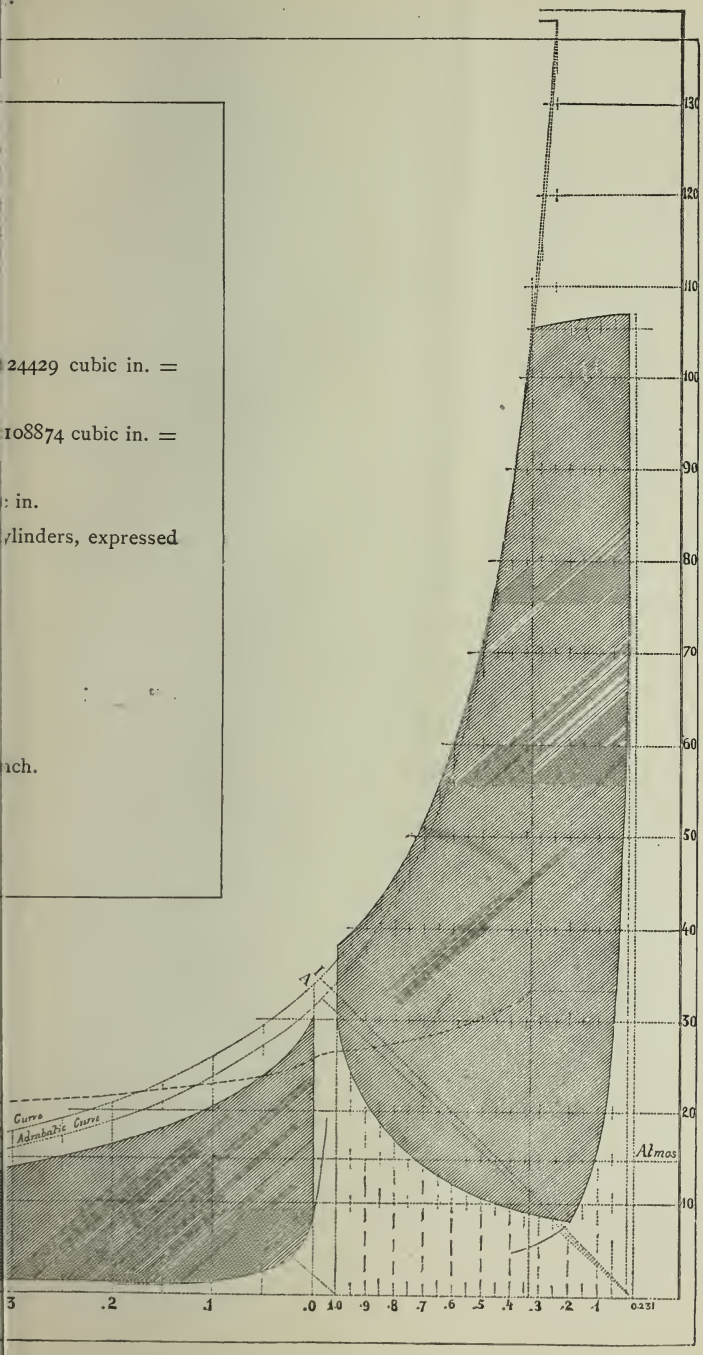
24429 cubic in. =

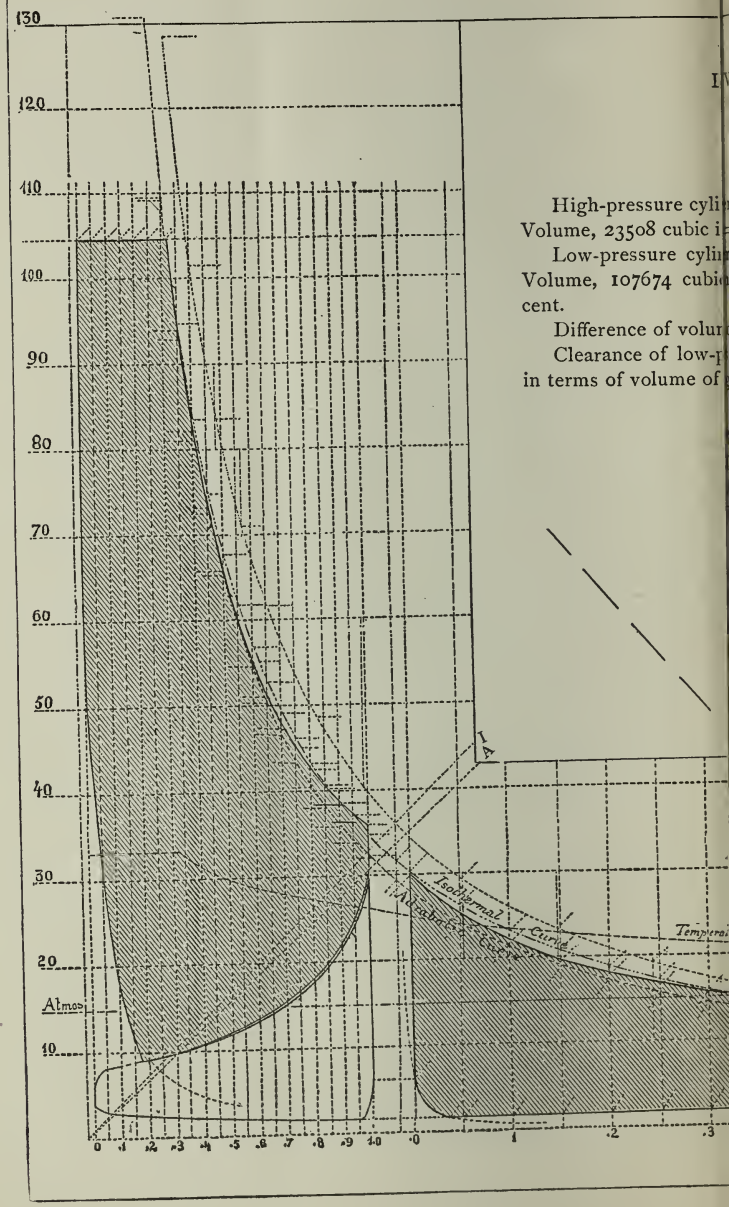
108874 cubic in. =

: in.

ylinders, expressed

nch.





I

High-pressure cyli
Volume, 23508 cubic i
Low-pressure cylin
Volume, 107674 cubi
cent.
Difference of volu
Clearance of low-p
in terms of volume of

VRENCE WATER WORKS,

May 4, 1876.

INDICATOR DIAGRAMS, UPPER END.

', 18 in. diameter, 96 in. stroke. Piston rod, 3.5 in. diameter.
= 13.6041 cubic ft. Clearance, 601 cubic in. = 2.56 per cent.
, 38 in. diameter, 96 in. stroke. Piston-rod, 4 in. diameter.
. = 62.1313 cubic ft. Clearance, 1135 cubic in. = 1.54 per

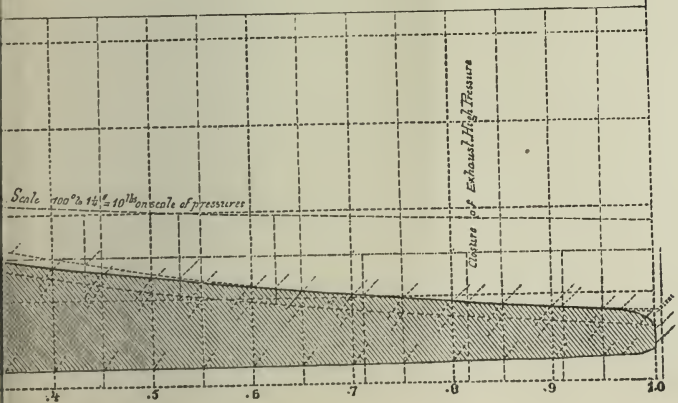
f cylinders, 107674 − 23508 = 84,166 cubic in.
ure cylinder, and difference of volume of cylinders, expressed
h-pressure cylinder, as follows:

135 ÷ 23508 = .048281 = 4.83 per cent.
1166 ÷ 23508 = 3.5803.
othermal curve, $p \propto v$.
diabatic curve, calculated by Rankin's formula, $p \propto v^{\frac{17}{16}}$.
arometer corrected 30.099 = 14.78 lbs. per square inch.

The difference between the two adiabatic curves shows the nount of water present in the stream at cut-off, evaporated by eat derived from the jacket; and the effect of the surface of ston-rods, acting as a surface condenser, in condensing steam uring admission, to be subsequently reëvaporated.

I axis of Isothermal curve.

A axis of Adiabatic curve.



ENGINE B—UPPER END.

MAY 6, 1876, 11.30 A. M. ELLIOTT INDICATORS. BAROMETER, CORRECTED, 30.099 IN. = 14.78 LBS.

PART OF STROKE.	Volumes in terms of Volume of High-Pressure Cylinder.	Measured ordinates, Pressure absolute.	Temperature, Fahrenheit.	Adiabatic curve begun at cut-off, P. 104.7.	Isothermal curve begun at cut-off, P. = 104.7.	Adiabatic curve begun at 11 times the fill, P. = 10.09.	
0.0	.0256	104.7	330.9°	.....	.....	.....	
0.5	.0756	104.7	330.9	.....	.....	.....	
.1	.1256	104.7	330.9	.....	.....	.....	
.15	.1756	104.7	330.9	.....	.....	.....	
.2	.2256	104.7	330.9	161.7	157.6	.....	
.25	.2706	104.7	330.9	130.7	129.0	.....	
.3	.3256	104.7	330.9	109.5	109.2	.....	
Cut-off....	.3396	(104.7)	(330.9)	104.7	104.7	1 = 128.6	(Cut-off)
.35	.3756	93.0	332.4	94.1	94.7	1¼ = 101.4	
.4	.4256	81.1	312.8	82.4	83.5	1½ = 83.6	
.45	.4756	72.6	305.2	73.2	74.8	1¾ = 70.9	
.55	.5256	65.5	298.3	65.8	67.7	2 = 61.6	(Exactly at 0.65 H. P.)
.55	.5756	60.0	292.5	59.8	61.8	2¼ = 54.3	
.65	.6256	55.1	287.0	54.7	56.8	2½ = 48.6	
.65	.6756	51.2	282.3	50.4	52.6	2¾ = 43.9	
.7	.7256	47.6	279.8	46.7	49.0	3 = 40.0	(Very near Level H. P. = 1.0256)
.75	.7756	44.9	294.2	43.5	46.0	.....	
.8	.8256	42.3	270.5	40.7	43.1	4 = 29.5	(Very near 0.05 L. P.)
.85	.8756	40.2	267.4	38.3	40.6	.....	
.9	.9256	38.4	264.7	36.1	38.4	5 = 23.25	(Very near 0.15 L. P.)
.95	.9756	37.0	262.5	34.1	36.5	.....	
1.0	1.0256	35.8	230.5	32.4	34.7	6 = 19.2	
Means....	.....	71.37	800.285 lbs. =57.5	.....	.....	.....	
.....	.....	.....	.....	.....	.....	7 = 16.3	
.....	.....	.....	.....	.....	.....	8 = 14.1	
.....	.....	.....	.....	.....	.....	9 = 12.45	
Cross Pipe	1.1248	.....	.....	29.3	31.6	.....	
0.0	1.1731	29.9	249.4	28.1	30.3	10 = 11.1	
.05	1.3521	24.9	239.8	24.1	26.3	.....	
.1	1.5311	21.7	232.3	21.1	23.2	11 = 10.06	Starting-point.
.15	1.7101	19.5	226.6	18.8	20.8	.....	
.2	1.8892	17.8	221.8	16.9	18.8	12 = 9.17	
.25	2.0682	16.3	217.2	15.4	17.2	.....	
.3	2.2472	15.2	213.7	14.1	15.8	13 = 8.42	
.35	2.4262	14.1	209.9	13.0	14.7	.....	
.4	2.6052	13.3	207.0	12.0	13.6	14 = 7.79	Near end of diagram.
.45	2.7842	12.6	204.3	11.2	12.8	.....	
.5	2.9633	11.9	201.5	10.5	12.0	.....	
.55	3.1423	11.4	199.4	9.9	11.3	.....	
.6	3.3213	10.9	197.3	9.3	10.7	.....	
.65	3.5003	10.5	195.5	8.8	10.2	.....	
.7	3.6793	10.1	193.6	8.3	9.7	.....	
.75	3.8583	9.7	191.8	7.9	9.2	.....	
.8	4.0373	9.3	189.8	7.5	8.8	.....	
.85	4.2164	8.9	187.8	7.2	8.4	.....	
.9	4.3954	8.5	185.6	6.9	8.1	.....	
.95	4.5744	8.2	184.0	6.6	7.8	.....	
Return....	4.5903	(8.0)	.....	.....	.....	.....	
1.0	4.7534	5.4	165.4	6.3	7.5	(At 4.7576)	
Mean.....	.....	14.1425	205.315 =12.855 lbs.	.....	.....	.....	

ENGINE B—LOWER END.

MAY 6, 1876, 11.30 A.M. ELLIOTT INDICATORS. BAROMETER, COUNTED, 30.099 IN. = 14.78 LBS.

PART OF STROKE.	Volumes in terms of Volume of High-Pressure Cylinder.	Measured ordinates, Pressures absolute.	Temperatures, Fahr., °.	Adiabatic curve begun at cut-off = vol. = .35 P. = 105.3.	Isothermal curve begun at cut-off, P. = 105.3.
0.0	.0231	106.6	332.2	.....	.....
.05	.0731	106.6	332.2	.....	.....
.1	.1231	106.5	332.1	.....	.....
.15	.1731	106.3	332.0	.....	.....
.2	.2231	106.0	331.8	172.5	167.6
.25	.2731	105.6	331.5	139.1	136.9
.3	.3231	105.4	331.4	116.4	115.7
Cut-off.....	.3500	105.3	.....	105.3	105.3
.35	.3731	99.5	327.2	99.9	100.0
.4	.4231	87.4	317.0	87.4	88.4
.45	.4731	78.5	310.5	77.6	79.0
.5	.5231	71.0	303.7	69.7	71.5
.55	.5731	65.0	297.8	63.3	65.2
.6	.6231	59.9	292.4	57.9	60.0
.65	.6731	55.6	287.6	53.4	55.5
.7	.7231	51.9	283.2	49.5	51.7
.75	.7731	48.4	278.8	46.1	48.8
.8	.8231	45.6	275.1	43.1	45.4
.85	.8731	43.4	272.1	40.5	42.8
.9	.9231	41.2	268.9	38.2	40.5
.95	.9731	39.4	266.2	36.1	38.4
1.0	1.0231	38.0	264.0	34.2	36.5
Means.....	.....	74.775	303.48 = 70.80 lbs.	.....	.....
0.0	1.1040	30.9	251.6	31.5	33.9
.05	1.2768	23.7	237.1	27.0	29.3
.1	1.4497	20.3	230.3	23.6	25.8
.15	1.6225	18.9	224.9	21.0	23.0
.2	1.7953	16.1	216.6	18.8	20.8
.25	1.9682	14.7	212.0	17.1	19.0
.3	2.1410	13.5	207.7	15.6	17.5
.35	2.3138	12.6	204.3	14.4	16.2
.4	2.4867	11.7	200.7	13.3	15.0
.45	2.6595	11.1	198.2	12.4	14.1
.5	2.8324	10.4	195.1	11.6	13.2
.55	3.0052	9.9	192.7	10.9	12.4
.6	3.1780	9.4	190.3	10.3	11.8
.65	3.3509	9.0	188.3	9.7	11.2
.7	3.5237	8.6	186.2	9.2	10.6
.75	3.6965	8.4	185.1	8.7	10.1
.8	3.8694	8.0	182.9	8.3	9.7
.85	4.0422	7.7	181.1	7.9	9.3
.9	4.2150	7.4	179.7	7.6	8.9
.95	4.3897	7.0	176.9	7.3	8.5
Return.....	4.4104	(6.8)	.....	.....	.....
1.0	4.5607	4.1	154.0	7.0	8.2
Means.	.....	12.295	199.645 = 11.45 lbs.	.....	.....

ENGINE B—UPPER AND LOWER ENDS—EXHAUST LINE.

MAY 6, 1876, 11.30 A. M. ELLIOTT INDICATORS.

	UPPER END.				LOWER END.			
PARTS.	Measured Volumes.	Measured Pressures.	Temperature, °.		Measured Volumes.	Measured Pressures.	Temperatures, °.	
0.0	.0256	63.0	295.7	0.0	.0231	75.5	307.8	
.05	.0756	31.5	253.1	.05	.0731	29.2	248.7	
.1	.1256	17.7	220.8	.10	.0231	15.2	213.7	
.15	.1756	11.4	199.4	.15	.1731	9.6	191.3	
Closure.....	.2006	(9.2)	.....	Closure.	.1888	(8.5)	.....	
.25	.2256	9.3	190.1	.2	.2231	8.3	184.5	
.25	.2756	9.7	192.5	.....	.2731	8.5	185.6	
.3	.3256	10.1	193.7	.3	.3231	8.7	186.7	
.35	.3756	10.5	195.5	.....	.3731	9.0	188.3	
.4	.4256	10.9	197.4	.4	.4231	9.5	190.8	
.45	.4756	11.5	199.9	.....	.4731	10.0	193.2	
.5	.5256	12.1	202.4	.5	.5231	10.5	195.5	
.55	.5756	12.8	205.1	.....	.5731	11.2	198.6	
.6	.6256	13.6	208.1	.6	.6231	11.9	201.5	
.65	.6756	14.6	211.6	.....	.6731	12.9	205.5	
.7	.7256	15.7	215.3	.7	.7231	14.0	209.6	
.75	.7756	16.9	219.1	.....	.7731	15.2	213.7	
.8	.8256	18.3	223.2	.8	.8231	16.8	218.8	
.85	.8756	20.1	228.2	.....	.8731	18.9	224.9	
.9	.9256	22.2	233.5	.9	.9231	21.0	230.5	
.95	.9756	25.3	240.7	.....	.9731	24.2	238.2	
1.0	1.0206	30.5	251.2	1.0	1.0231	31.0	252.1	
Means.....	.....	17.0475	{ 215.2775 = 15.70 lbs.	.....	.....	15.8925	{ 209.9775 = 14.12 lbs.	215.28 209.98
							2)	425.26
Means of both ends.....	.....	.....	212.63	.....	.....	.....		212.63
Jackets.....	.....	.....	330.90	.....	.....	.....		330.96
Difference.....	.....	.....	.....	.....	.....	.....		118.33
Cross Pipe.....	1.1248	.....	.....	.....	.....	.....	.....	
0.0	1.1731	5.9	169.3	0.0	1.1040	8.6	186.8	
Closure.....	1.2231	(1.6)	.....	.....	.....	.....	.....	
.05	1.3521	1.6	116.6	0.5	1.2768	2.3	130.9	
.....	.....	.....	.....	Closure.	1.3563	(1.4)	.....	
.1	1.5311	1.6	116.6	.1	1.4497	1.4	111.7	
.15	1.7101	1.6	116.6	.....	1.6225	1.3	109.3	
.2	1.8892	1.7	119.0	.2	1.7953	1.3	109.3	
.25	2.0682	1.7	119.0	.....	1.9682	1.3	109.3	
.3	2.2472	1.7	119.0	.3	1.1410	1.4	111.7	
.35	2.4262	1.7	119.0	.....	2.3138	1.4	111.7	
.4	2.6052	1.8	121.4	.4	2.4867	1.4	111.7	
.45	2.7842	1.9	123.8	.....	2.6595	1.5	114.1	
.5	2.9633	1.9	123.8	.5	2.8324	1.5	114.1	
.55	3.1423	2.0	126.3	.....	3.0052	1.5	114.1	
.6	3.3213	2.1	127.8	.6	3.1780	1.5	114.1	
.65	3.5003	2.2	129.3	.....	3.3509	1.6	114.1	
.70	3.6793	2.3	130.9	.7	3.5237	1.6	116.6	
.75	3.8583	2.3	130.9	.....	3.6965	1.7	119.0	
.8	4.0373	2.4	132.4	.8	3.8694	1.8	121.4	
.85	4.2164	2.5	133.9	.....	4.0422	1.9	123.8	
.9	4.3954	2.6	135.5	.9	4.2150	2.0	126.3	
.93	4.5744	2.8	138.6	.....	4.3879	2.2	129.3	
.....	4.7060	3.1	150.8	.....	4.5089	2.5	.....	
1.0	4.7538	3.8	.....	1.0	4.5607	3.2	143.9	
Means.....	.....	2.1625	{ 127.0225 = 2.05 lbs.	.....	.....	1.825	{ 118.5175 = 1.68 lbs.	127.02 118.52
							2)	245.54
Means of both ends.....	.....	.....	.....	.....	.....	.....		122.77
Jackets.....	.....	.....	.....	.....	.....	.....		330.96
Difference.....	.....	.....	.....	.....	.....	.....		208.19

FIG. 1.

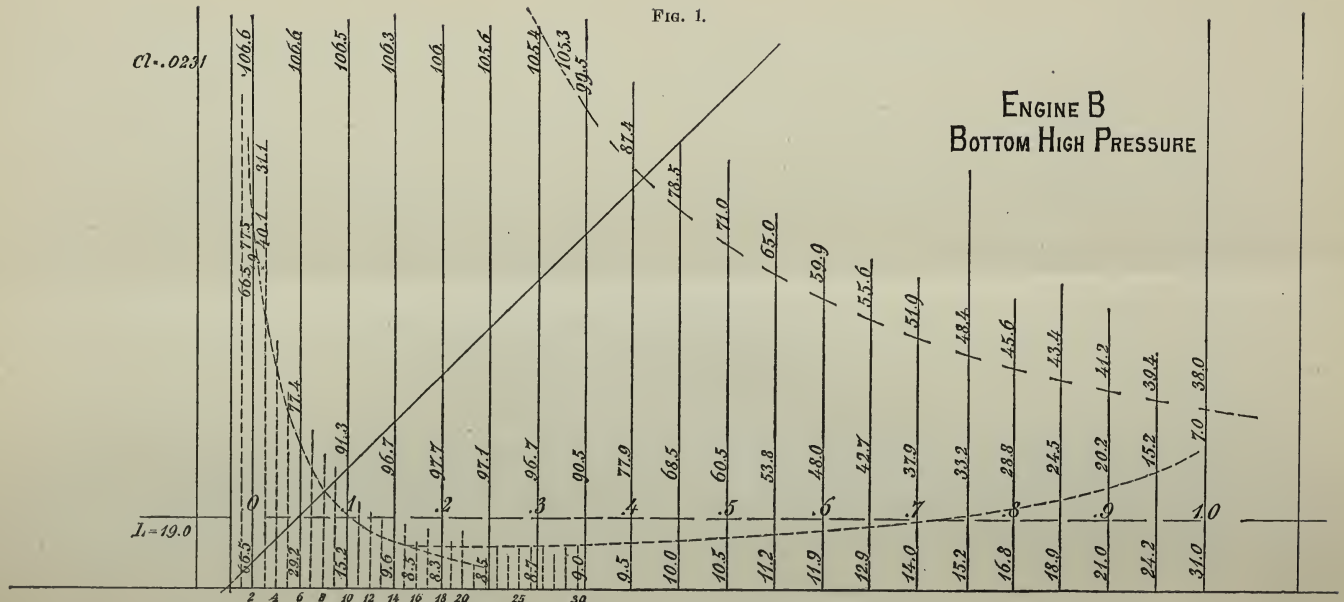
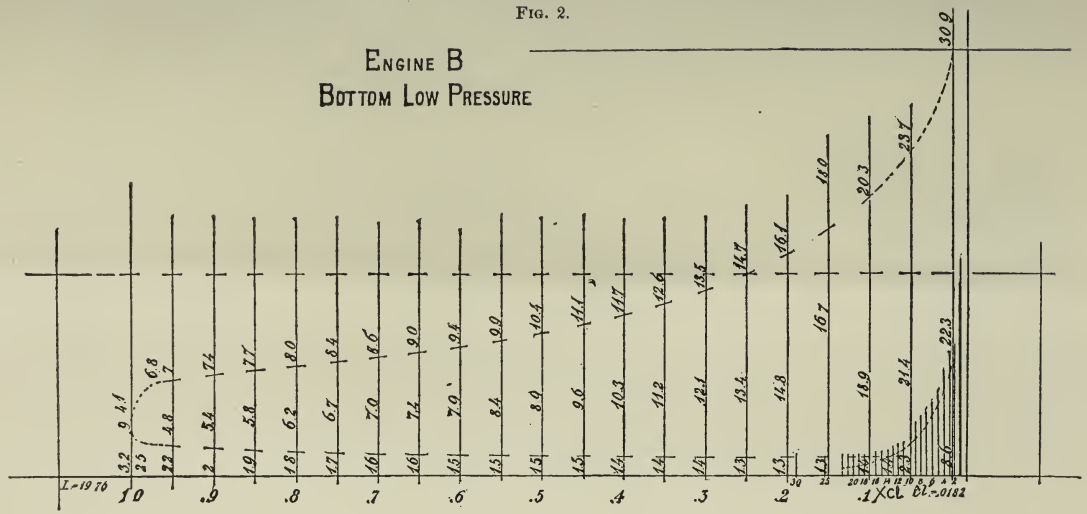
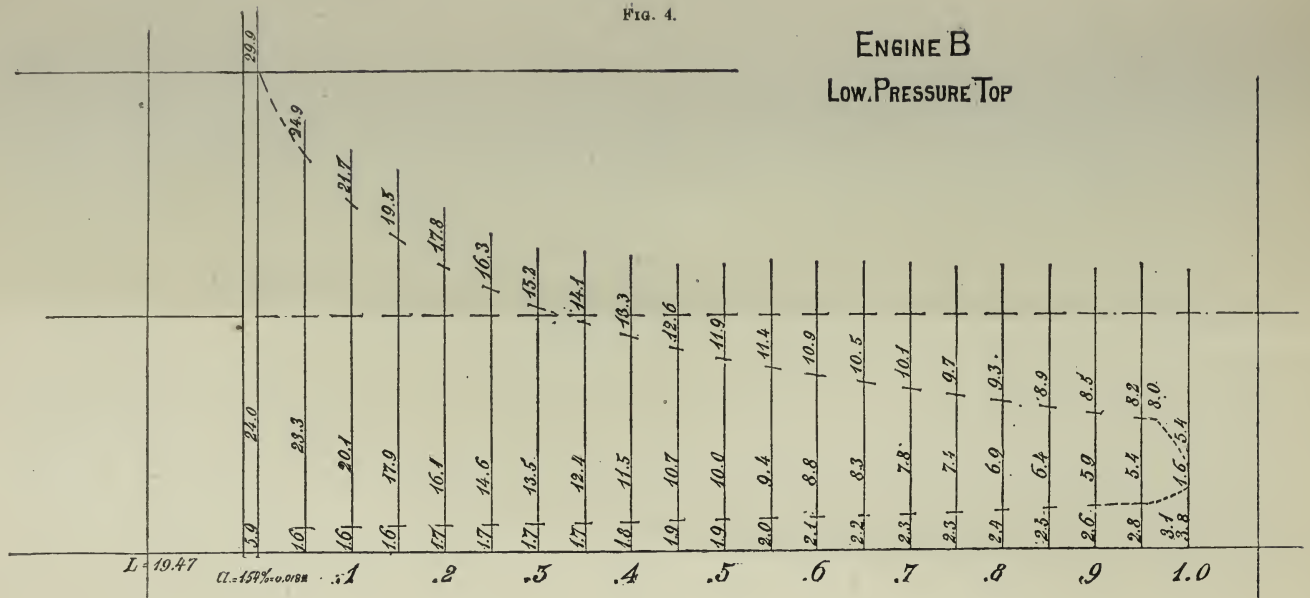

ENGINE B
BOTTOM HIGH PRESSURE
Cl=.0231
I_1=19.0
106.6
106.6
106.5
106.3
106
105.6
105.4
105.3
99.5
87.4
73.5
71.0
65.0
59.9
55.6
51.9
48.4
45.6
43.4
41.2
30.4
33.0
66.5
77.5
40.7
31.7
75.4
29.2
75.2
91.3
96.7
97.7
97.1
96.7
90.5
77.9
68.5
60.5
53.8
48.0
42.7
37.9
33.2
28.8
24.5
20.2
15.2
7.0
8.3
8.3
8.3
8.3
8.7
9.0
9.5
10.0
10.5
11.2
11.9
12.9
14.0
15.2
16.3
18.0
21.0
24.2
31.0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
2
4
6
8
10
12
14
16
18
20
25
30

FIG. 2.



ENGINE B
HIGH PRESSURE TOP
cl = .0256.
L = 19.8
0
58.0
31.5
13.2
11.7
67.8
14.7
93.3
9.2
9.3
93.4
6
9.3
9.7
93.0
10.7
94.6
5
10.3
82.5
93.0
10.9
70.2
4
81.1
11.5
64.1
72.6
12.1
53.4
65.5
4
12.8
47.2
60.0
13.6
41.5
55.1
3
14.6
36.6
51.2
15.7
31.9
47.6
2
16.9
28.0
44.9
18.3
24.0
42.3
1
20.1
40.2
22.2
16.2
38.4
6
25.3
41.7
37.0
30.5
7.0
35.8
53
104.7
104.7
104.7

FIG. 4.


ENGINE B
LOW. PRESSURE TOP
L = 19.47
Cl. = 15% = 0.0188
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
29.9
24.9
21.7
19.5
17.8
16.3
15.2
14.1
13.3
12.6
11.9
11.4
10.9
10.5
10.1
9.7
9.3
8.9
8.5
8.2
8.0
5.4
24.0
23.3
20.1
17.9
16.1
14.6
13.5
12.4
11.5
10.7
10.0
9.4
8.8
8.3
7.8
7.4
6.9
6.4
5.9
5.4
1.6
5.9
1.0
1.6
1.6
1.7
1.7
1.7
1.7
1.8
1.9
1.9
2.0
2.1
2.2
2.3
2.3
2.4
2.5
2.6
2.8
3.1
3.8

3 0112 098430710